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FRENCH NAVAL ENGINES.

CRITICISMS AND ANSWERS—LIGHT MARINE ENGINES—HISTORY OF HIGH EXPANSION—NORMAND'S SYSTEM.

Translated from "Annales du Génie Civil."

In our last number we published the sharp criticisms of "Engineering" on our navy. M. Belleville, in a discussion of a memoir of M. Normand, has replied to these criticisms which, under the influence of a patriotic anxiety, have been much exaggerated; and our readers will see that if, as MM. Mallet and Normand have shown, we can improve vastly in the engines used in our ships, we have long been in advance of other nations in the improvements made upon hulls and propellers. MM. Normand and Mallet intended in their memoir to give an accurate *resumé* of all the improvements which have been made in marine engines, and a table showing the progress made at the principal centers of ship building in the Old World and the New, and they proposed to show the arrangements which must be adopted in marine machinery, if we expect to get rid of the errors in vogue among naval engineers. The problem of the best system of marine machinery consists entirely in the determination of the best results in three classes of economy. We give them in the order of their relative importance: 1st. Economy of weight. 2d. Economy of fuel. 3d. Economy in expenses of capital, in repairs, in the *personnel* and accessory expenses. These various kinds of economy are not inconsistent with each other.

MM. Mallet and Normand have summed up in four graphic tables the results obtained by experiment from more than one hundred engines. The first represents the weights of the machinery complete (engine, boiler, water and propeller) in horse powers of 75 kilogrammeters measured by the indicator on the pistons. The second shows the actual development of power measured by the indicator per nominal horse power. The third shows the consumption of fuel per indicated horse power of 75 kil. met. The fourth shows the total weight of the entire machinery, with fuel enough for five days' steaming with maximum power. Each of these tables will show at a glance the great difference in the results given by the various systems which are or which have been in use. We may thus determine the disadvantageous position occupied by the French navy with respect to its prime movers. This inferiority has been general for a quarter of a century, and is continually getting worse. It is an indisputable fact to-day that the English vessels recently built can develop an actual power nearly double that of the vessels in the French fleet. The development per nominal horse power which in the Imperial marine has never yet reached 300 kil. met., is fixed for the new English vessels at 450 and in some of them exceeds 500 kil. met.

The weight of engines per unit of actual power is the most important question, and it is upon this point that the widest differences with respect to economy occur. The total weight of the machinery, including boilers, may be resolved into its elements. The steam generating apparatus, consisting of elements in some sort alike (grates, flues or boilers), differ only in the number of parts. The total weight of boilers and water is then, for each system, sensibly proportional to the power to be developed. In the

engine proper the case is different—for the same system the weight varies in a higher ratio than the power. Notwithstanding the many modifications introduced into the construction of engines and boilers, the ratio between the fraction of weight which is always constant, and the fraction which varies with the velocity of the engine, is not sensibly changed. In taking for a unit of weight the weight due to a velocity of one revolution per second, we may express the relation for all other velocities by the formula—

$$P = \frac{2}{3} p + \frac{1}{3\,n} p.$$

The following figures indicate the total weights per indicated horse power, corresponding to each of the great classes of marine engines:

No. of revolutions per minute.....	15	20	30	60
Old beam engines with flue boilers.....	660 kg.	550 kg.	440 kg.	330 kg.
Direct acting engines with tubular boilers.	420	350	280	210
Same engine of John Penn's system.....	300	250	200	150
Limits of the lightest engines of the present day	240	200	160	120

These figures show the vast progress made during the last 25 years in reducing the weight of machinery. Between the first Cunard packets and the present transatlantic propellers the weight has undergone a reduction from 660 kil. down to 180. This reduction is the result of three forms of progress: 1st. The substitution of tubular for flue boilers. 2d. The substitution of direct acting engines for more complicated ones. 3d. The greater rapidity of revolution, due partially to increase in the velocity of the vessels, but especially to the substitution of the propeller for the paddle. Beside those considerations belonging to the degree of excellence in the construction, such as the forms and proportions of the various parts, the use of stronger materials which will allow a diminished thickness, the weight per unit of power developed, &c., the ultimate economy is largely dependent upon the functional action of the steam upon the engine. The conditions of lightness are much improved in large engines by a more advantageous use of the steam, and by the better draft obtained by high chimneys, which can be employed only on large vessels.

Altogether, the results obtained by MM. Normand and Mallet may be summed up as follows:

The old low-pressure flue boilers weigh, on an average, 250 kil. per indicated horse power, and 20 kil. per kil. of steam per hour. In the greater portion of the boilers of Imperial type, these values are reduced to a mean of at least 140 and 13 respectively. In English machinery these weights are only 110 and 10 kil. respectively. In the boilers of the Francis I, built by M. B. Normand, the exclusively cylindrical forms given to the shells and grates, together with the substitution of steel for iron plate, have reduced the weight to 7 kil. per kil. of steam per hour. The combination of these steam generators with the economically working engine has reduced the weight per indicated horse power to 50 kil.—an economy which has never before been reached in any marine boiler.

M. Normand then proceeds to inquire into the conditions which regulate the weights of the other parts of marine machinery, viz: the engine proper and the propeller. Nearly every part has at least one of its dimensions determined by the intensity of the effort which it is to receive or transmit; the weight of every mechanical part then should be sensibly proportional to the amount of work developed by a single revolution. The final development of power as related to the time being proportional to the rapidity of revolution, which in turn is governed by elements dependent upon the vessel, the correct value of the conditions of lightness will be furnished by an expression which MM. Normand and Mallet have employed for the first time (so far as they know), in these investigations. It consists in approximating the weight to a standard corresponding to a uniform velocity (or speed), the weight being inversely proportional to the power due to two-thirds the number of revolutions. Two tables furnished by MM. Normand and Mallet give the economy of weights in paddle and screw engines. In beam engines with paddles, the weight is 1.5 kil. per kil. met. of indicated work per revolution. This weight is between 1 kil. and .80 kil. in a majority of the modern direct acting engines, and in the lightest on the Penn plan it is as low as .60 kil. The weight per indicated horse power shows some extreme variations in consequence of the introduction of another element of inequality, viz: the variable rate of the engines. The weight corresponding to a horse power of 75 kil. met., which in the old beam engines often reached 350 to 400 kil., does not exceed in the most per-

fect modern engines 150 kil. for the large ones, nor 100 or even 70 kil. for moderate sized and small ones. Screw engines, even the more recent ones, show similar diversity in the economy of weight. The graphic tables alluded to show clearly the errors and mistakes in construction already pointed out by M. Normand. The engines of the Imperial marine are classed between 1.60 and 1.20 kil. per kil. met. per revolution, while the engines of Penn and Maudslay do not exceed .80 or even .70 kil. For weights per indicated horse power, almost all the engines of the Imperial marine are between 150 and 110 kil., while the English builders just cited do not exceed for the largest engines 70, or perhaps even 60 kil. John Penn, in the yacht Le Grille (engine of small size and great speed), has reduced this weight to 30 kil.

But the question of economy of weight in steam engines is intimately connected with that of the advantageous use of steam and consequent economy of fuel. The once admitted laws of expansion are acknowledged to be incorrect, and the tables of cut-off now in use stand in need of correction. MM. Normand and Mallet present a new table of cut-off which they have collated, keeping in view the three following classes of corrections: 1st. For the reductions of temperature corresponding to varying pressure. 2d. For the portion of steam condensed, which, with the reduced temperature, makes up the loss of heat corresponding to the work done. 3d. For the resisting pressure of the condenser. In the calculation of heat consumed by the work done, each unit of heat (*calorie*) has been calculated as corresponding to 400 kil. met. The back pressure of the condenser, which varies from three to six per cent of the boiler pressure, has been made equal to four per cent of the initial pressure. By economy of agents (*organes*) the authors mean the relation existing between the mean effort of the whole stroke of the piston and the maximum effort under initial pressure. The data of cut-off have been made to correspond with the performance of a majority of marine engines with an admission of $\frac{2}{3}$, and not with an admission over the whole length of stroke. Finally, the table has been calculated for an initial pressure of five atmospheres. The values should be slightly increased for lower pressures and diminished for higher.

It must be inferred from these tables that all engines constructed up to a very recent date, however different in plan, show no differences in the economy of steam, at least as to the maximum useful effect obtainable from it. If differences occur, they are the reverse of economy. Notwithstanding the marked increase in the tension of steam, which in the last 20 years has been raised from $1\frac{1}{2}$ to $2\frac{1}{2}$, or even 3 atmospheres, no economy of fuel has been obtained. On the one hand, the experiments of a $\frac{2}{3}$ expansion have led only to mistakes, and on the other the increase of pressure has been offset by disadvantages in the distribution and condensation of the steam. These disadvantages are most conspicuous in engines at high speed. The ordinary marine engine gives an indicated horse power with a theoretical expense of 12 kil. of steam, which represents a consumption of $1\frac{3}{4}$ to $2\frac{1}{2}$ kil. of coal.

At the commencement of this state of affairs it was conceded that the expansion principle offered a boundless field of improvement. Yet it was thought (and perhaps not wrongly) that it would be well to imitate the most advanced products of ingenuity and use the most economical kinds of engine, particularly the draining engine of Cornonailles and the Woolf engines, the cost of which was about half that of the marine engine of that day. But the objections were many. One of these types was heavy, cumbersome, complicated; the double expansion was impracticable on the water, and the pressure must not exceed a defined limit. Facts have demonstrated that an economically working engine not only can be built within the conditions of weight of engines of high expansion, but that a more perfect action of the steam may be a source of still further progress in the economy of weight.

The following history of progressive improvements is succinctly given by MM. Normand & Mallet.

In 1856 Rowan & Horton constructed marine engines on the Woolf plan, with surface condensers, and working at a pressure of 8 or 9 atmospheres, which, however, was practically found to be inconvenient. Randolph & Elder endeavored to increase the expansion by the use of larger cylinders instead of augmented pressure. They succeeded in obtaining good results with expansion under a pressure not exceeding 3 or perhaps $2\frac{1}{2}$ atmospheres. In 1861, Humphreys, following the same path, introduced engines with large cylinders, having small

ones superposed. The English engine builders all agree in using a large amount of expansion with surface condensers, steam jackets and superheating. Lastly, M. Normand claims to be the representative of French ingenuity in this struggle for maritime progress, and some significant facts seem to show that the improvements which he was the first to elaborate and carry forward successfully cover the greater part of the problem of the economical marine engine. His attempts go back as far as 1854. The main idea in the Normand system consists in dividing the total expansion between two cylinders, which are entirely independent of each other in respect to their movements, though capable of attachment to the same shaft by cranks at right angles, an essential feature in the marine engine. These cylinders communicate with an intermediate reservoir, where the steam escaping from the first cylinder is relieved of the condensation resulting from the work done, and receives a certain addition of heat before entering the second cylinder. This simple plan constitutes a marine engine with all the advantages of a double expansion and without any increase in the number of parts. It can with suitable modification be applied to any existing engine, and has already been used in small vessels of high speed. With respect to economy of steam its superiority is very decided. With a cut-off at $\frac{1}{4}$, the economy is .92 against .52 in ordinary engines. With a cut-off at $\frac{1}{10}$, the economy is still .54 against .26. The average admission in the two cylinders of M. Normand was in the first .65 and in the second .40.

The advantages of M. Normand's system were officially recognized in 1860 by a commission appointed by the minister of the marine. One of his engines was placed upon the transport Loiret, of the Imperial navy. It had the double expansion, the independent movement of the pistons, with the intermediate reservoir for drying and reheating the steam. Subsequently it was put into a number of frigates with 950 nominal horse power, and into four corvettes, with 450 nominal horse power, &c., &c. He has also applied his system to some fifty engines, marine and stationary, with even better results than those obtained in the navy, though the principles are the same. It was in some engines built in the government dock yards that he obtained the highest actual power, and that with a large expansion and no increase in the size of the cylinders, making a saving of 500 indicated horse power. This is the mean deficiency of the armored frigates, and it serves to show how erroneous have heretofore been the principles upon which their engines were constructed.

With respect to economy of fuel, results have been more favorable. The consumption has been reduced to 1.44 kil., while in the engines built by M. Normand himself this consumption is still less by one-fourth. We give below the relative values of the cut-off in various systems:

	Cut-off at—	Saving.
Old marine engines	$\frac{2}{3}$	1.
Dupuy de Lôme	$\frac{2}{5}$	1.30
Normand	$\frac{2}{9}$	1.60
Humphreys	$\frac{1}{6}$	1.74
Rowan & Horton	$\frac{1}{8}$	1.84
Randolph & Elder	$\frac{1}{10}$	1.90

If it is desired to obtain the greatest lightness of engine with the greatest economy of fuel, the cut-off should be varied according to the distance to be run. M. Normand gives the following table:

1 day,	rate of	expansion,	4 or	5	volumes.
5	"	"	5 or	6	"
10	"	"	6 or	7	"
15	"	"	7 or	8	"
20	"	"	8 or	10	"

In view of the faulty imitations of his work, M. Normand finds great pleasure in presenting the results of an engine put into the Francis I—a passenger vessel running between Havre and Trouville, or Honfleur. The nominal power is 100 and the developed power 550; consumption of fuel per indicated horse power, 1.10 kil.; speed, 26 kilometers; boiler pressure (*le timbre des chaudières*), 4 atmospheres. Total weight of machinery, including 11,000 kil. of water, 56,500 kil.

The Normand system has just been adopted by the General Transatlantic Company for their packets of 450 horse power, which are to be built for their new Pacific line.

As a supplement to the communication of M. Normand, and his observations on the law of the pressure of expanding steam, M. Duprez has published the results of some calculations relative to the work of 1 kilogramme of steam in high pressure engines without condensers, and where the expansion is carried on until the tension becomes equal to 1 atmosphere. The following are the

resulting ratios of heat utilized to heat expended:

Initial pressure in atmospheres	8	10	12
Ratios	0.1501	0.1633	0.1771

Hence the increase of useful effect would be 18 per cent if the pressure were carried to 12 atmospheres instead of 8; in other words an engine working at 8 atmospheres and consuming 100 kil. of coal would consume only 84.7 at a pressure of 12 atmospheres, with an expansion to a pressure of 1 atmosphere. The advantage would be still greater if the final pressure were as low as it is in marine engines. These results are in accordance with the method laid down in the work of M. Combes on the mechanical theory of heat, but it assumes that there is no loss of heat by conduction and radiation.

M. Belleville, who has been connected with the Imperial marine since 1853, has obtained meantime some accounts which he thinks do not harmonize altogether with the views of MM. Normand & Mallett. The value of a war vessel does not depend solely upon the greater or less effective force of her engines as compared with their nominal power, nor yet upon the diminished weight of machinery, but as well upon the economy of power, speed obtained, facility of evolution, resources of battery—in short, upon whatever determines fighting qualities and seaworthiness. In 1850 no navy in the world had steam vessels capable of competing with the old sailing craft. England had three or four steamers used as a coast guard, which might sail, with steam alone, 7 knots. At this juncture was launched at Toulon the first steamer which was to solve the vexed problem of great speed united to all of the sea qualities possessed by the better class of sailing vessels. The Napoleon, a product solely of French naval engineering, and furnished with an engine of 900 horse power (nominal), the largest then in existence, has justified all expectations. This purely French achievement served as the type for the creation of new fleets, both in France and elsewhere, and the Napoleon is still considered one of the best wooden war steamers afloat. Her excellent results have been achieved not only in experiments but in actual service. During the Crimean war, when the French squadron were ordered to pass the Dardanelles, the Napoleon, having in tow the three-decker Ville de Paris, accomplished it easily in the face of a powerful head wind which compelled the English fleet to anchor and wait a whole week for favorable weather. After the launch of the Napoleon, England put the Agamemnon upon the stocks—a vessel of the Napoleon type, of almost identical dimensions, and differing only in a little lighter draught. The Napoleon had 2.602 indicated horse power, the Agamemnon 2.206; the speed of the former is 13 knots, of the latter 10 knots. The co-efficients of useful effect are respectively 2.125 and 1.86. In France all vessels put upon the stocks by the Imperial marine were built upon the plan of the Napoleon. In England the same sort of idea was followed, with some variations. The experimental vessels Algesiras and Marlborough offered a further comparison:

	Ind. H.P.	Speed.	Useful effect.
Algesiras	2,696	13.37	2.244
Marlborough	2,718	11.5	1.86

With one-half fires the Algesiras gave 1.742 horse power and 11.66 knots, with a coefficient of useful effect 2.306.

In 1856 the French naval engineers built the armored frigate La Gloire—an undertaking ridiculed by English engineers and scribblers. Their criticisms also became known in France. But the results have vindicated the promoters of this bold project. The plated floating batteries which had been built in France and England after the Crimean war were merely floating forts, while armored vessels having the sea going qualities of wooden ones were then altogether unknown. In this matter England followed the example we set her, and started the construction of a fleet upon our new ideas.

M. Belleville has acquainted us with the composition of the two fleets, showing for each vessel the power, speed and coefficient of useful effect, and from his tables he derives the following mean results for armored vessels:

	Speed, knots.	Coeff. of useful effect.
French	13.718	2.176
English	12.939	1.878

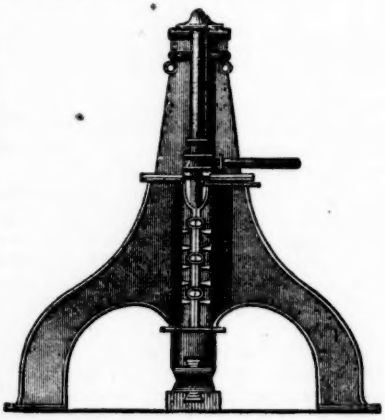
On the whole France has led the march of improvement for the last 15 years. Successive engines have been perfected in the Imperial works in which the weight has been reduced and the consumption of fuel decreased. At present the Woolf engines are used, and the consumption of fuel has been reduced to 1.3 kil. on the Magnanime, and to 1.240 kil. on the Jeanne d'Arc, and that without surface condensers. M. Belleville

is confident that all the new engines will be provided with surface condensers, and that before long steam at high pressure will also be used, which has not yet been done except upon gunboats and similar structures. Finally, M. Bellville believes that M. Normand's figures relating to the indicated power of the French fleet are too small, while those relating to consumption and to the weights are too large. M. Flachat remarked that M. Belleville did not answer directly the observations of MM. Normand and Mallet, who had examined exhaustively only the marine engine.

Progress in this branch of science has been gradual. First came the screw, with engines of quick stroke and consequently small dimensions; then steam jackets, superheating, surface condensation, and finally high pressure with high expansion. The surface condenser enables the boiler to be fed with distilled water, and prevents incrustation, making the iron plates better conductors of heat and more durable. This step in advance was accomplished in England by MM. Randolph and Elder, but M. Normand had urged it long before, and has finally established it in France in the face of difficulties which the Englishmen did not have to encounter. M. Flachat reviews the successive transformations of marine steam engines, and shows that the Transatlantic Company, whose origin does not go far back, is now making its third transformation. After nine years' service the Royal Mail is also, after a most varied experience, exchanging paddles for screws, with the boilers of Randolph and Elder. The history of the Imperial Company, of the Peninsula and Oriental, of the Cunard—in short, of all companies, is but a long series of renovations and progress. This summary of facts which daily modify our naval material shows the technical importance of the questions to which MM. Normand and Mallet have drawn the attention of the Society. In England progress in this path is very rapid, but in France there are administrative regulations applying to the marine boiler of large diameter and high pressure. It is fortunate that locomotive engines have smoothed the way in this respect, and that the recent progress in the fabrication of plate iron came seasonably to aid in the solution of this question.

MM. Normand and Mallet present some remarks in reply to the strictures of MM. Belleville and Flachat. They state that M. Belleville speaks of vessels in their *ensemble*, while they have confined their investigations to the machinery. They accept some numerical corrections of M. Belleville, as to the power of engines, but insist the correctness of the sources whence they derive their figures should be admitted. They adhere to what they have said as to the inferiority of French engines, in which the useful effect reaches but two-thirds or perhaps only one-half the standard of the English marine.

IMPROVED STEAM HAMMER.—The engraving shows a new style of fifteen ton steam hammer, by Messrs. Thwaites & Carbutt, of Bradford, England.

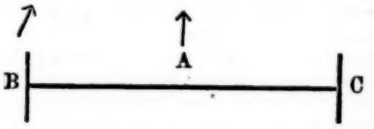


The peculiarity of this hammer consists in joining the standards, which are of the best patterns, boring them out, and putting in a round core. This gives great strength and stiffness, besides more efficiently guiding the hammer. The standards, which are 20 tons in weight, are 20 ft. apart, and give 8 ft. 6 in. headroom. These are bolted to a bed plate made in three pieces, and are also fastened by wedges driven between the lugs, which are cast on the plate. A balance piston valve is placed in the same casting as the stop valve, so as to save the joints of a separate stop valve. The anvil weighs 120 tons, and is placed on two rows of 18 in. sq. oak, laid in a cut stone foundation. The foundation of the block is kept as separate as possible from the side-wall foundations for the bed plate which carries the standard, so that the jerk and spring of the one is not communicated to the other.

IMPROVED RAILWAY RUNNING GEAR—LOOSE WHEELS.

Among the many barbarisms that characterize our railway practice, the sliding of half the wheels in a train, upon every curve in the line, by reason of their rigid connection to the axle, is one of the most wasteful, although it has been one of the most difficult to overcome. Lines of easy curves are not exempted from the evils resulting from the greater length of the outer rail. It is not so much the sliding of a wheel a few feet more or less, after it is started, but it is the starting of the slipping, that consumes power and material, and brings the sudden and heavy torsional strain upon the axle. Even on air lines, the difference in the diameter of wheels—often amounting to ½ inch in one revolution—keeps the axle in an almost perpetual state of torsional strain, and wears the tread of both rail and wheel by an unbroken series of little scrapings, from one end of the road to the other. But the wear is not the only evil. The lurching and jarring of the whole running gear from this cause, and more especially the twisting of the axle back and forth at every curve, thus seriously weakening an iron axle, if not excessively heavy, require a degree of massiveness and non-paying load that could be greatly reduced by making the wheels independent. Precisely what the saving in friction might be, it is impossible to state, because we have no prolonged tests of a thoroughly practicable apparatus. But it is reasonable to assume that with the present apparatus the friction and the general wear and tear of running gear, and the extra non-paying load thereby made necessary, add at least 20 per cent to the normal power required for traction.

Many devices to meet this difficulty have been tried, and many more have been invented. The most obvious direction of improvement is in using a simple loose wheel. One wheel has been cast with a deep hub, so as to give a long bearing on the shaft, and some experimenters have even gone to the trouble of fitting boxes into the hub to take up the wear. But after every nicety of fitting and adjustment, the car had a perverse, uniform, incurable, and, to most experimenters, inexplicable tendency to run off the track; the wheel fastened to the axle was always crowding the rail. This tendency cannot be cured; it can only be avoided by abandoning this plan altogether. A simple analysis of the forces will make this evident. The two axle-boxes and the superincumbent load rest upon the two ends of a continuous axle. Upon one end of this axle a wheel is rigidly fastened; upon the other end there is a loose wheel. In the first place let us suppose that the axle, B C in the diagram, instead of being free to move in the axle-boxes, is rigidly held by them, so that it cannot turn. A power is applied, in the direction A, to the middle of the truck. Since the wheel C cannot turn,



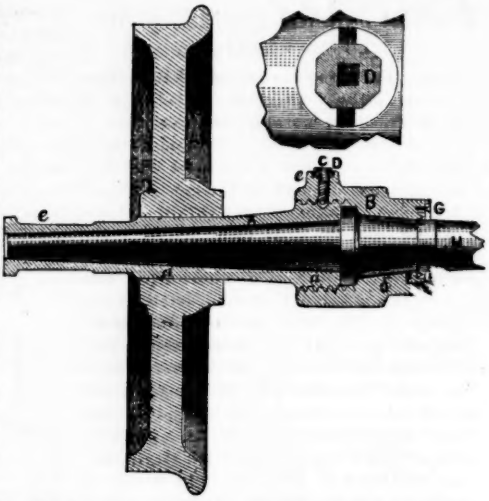
it will tend to slide, and thus require a great exertion of power. But the wheel B can turn, and the end B of the axle, and with it the truck, will be pulled in the direction of the arrow B, while the end C will stand still. It is a simple case of a lever with the fulcrum at C and the power at A. Now, if we loosen the axle-boxes a little, so that the axle will just be able to turn in them, the effect will be the same in kind, but less in degree. The power required to turn the axle in the axle-boxes is still so much in excess of the power required to turn the loose wheel B on the axle, that the end C will be retarded and the truck will run off the track. Just in proportion to the amount of axle friction, will this be the tendency. The forward motion of one side of the truck, or one end of the axle, is retarded by the friction of *both* journals.

This difficulty may, indeed, be avoided by making both wheels loose, but the cost and weight of an apparatus which should give sufficiently long bearings, for safety and stability, would be considerable. Another plan is the division of the axle in the center. The sleeve joining the two ends must be so long and heavy, and the fittings and details for oiling, adjustment, etc., so expensive, that two internal journal-boxes, on a middle beam of the truck frame would perhaps be a better arrangement, and this would be neither cheap nor light.

The difficulties we have mentioned have been, we think, very successfully avoided in the axle shown in the engraving.* It is

* Patented by D. M. and A. G. Cummings. Proprietors, Cummings, Wells & Godfrey, Enfield, N. H.

simply a solid iron or steel axle, made smaller at one end to receive a loose steel sleeve, upon which the wheel is fastened, and upon which also the journal-box rests. The opposite wheel is made fast to the axle in the usual manner. The sleeve is 24 in. long, bored at the ends to fit the axle, but counter-bored slightly in the middle to give slight flexibility. The small end of the axle is 1¾ in. diameter; the large end of the taper is 3¾ in diameter. At this point there is a 6 in. fast collar, from which the axle tapers the other way towards its center. The steel sleeve is held against the collar by a loose collar B, eight inches long, which is screwed upon the end of the steel sleeve. The axle is of the full size, where this loose collar comes, so that the strength is not dependent upon the latter. The collar, however, increases the length of the bearing of the steel sleeve upon the axle to 30 in. The loose collar is kept from unscrewing by the three set screws C (shown in plan in the upper figure), and these set screws are kept from unscrewing, by a washer D fitting into the recessed boss c of the loose collar B. By slightly riveting the opposite corners of the set screw over the washer, the latter is kept in place. Should the bearing between the axle and the steel collar wear, the lost motion may be taken up by withdrawing the set screws, facing off the end of the steel sleeve, and screwing up the loose collar. Oil from the axle-box will be constantly thrown, by centrifugal force, up the inclined portion of the axle, so as to keep all these parts lubricated. The oil may be prevented from escaping, and dust from entering, at H, by means of a hydraulic packing leather and plate G, F. The details have been very thoroughly worked out by a skillful mechanic.



It will be observed that the strength of the axle is not impaired. Although the internal axle is small, the external steel sleeve brings the whole structure up to full size. Experiments upon hollow axles show that the sleeve would be nearly or quite as strong bored out as if solid. The additional weight is chiefly that of the loose collar B.

We learn that several sets of these axles are being fitted up for trial on the Pennsylvania and other roads.

STEAMSHIP PERFORMANCE—THE KŒNIG WILHELM.

In a previous number* we gave the particulars and performances of one of Mr. Reed's new iron-clads—the Hercules. The remarkable results of Messrs. Penn's engines, in this vessel, have been largely commented upon in the technical press. We now quote from "Engineering" some particulars of another of Mr. Reed's vessels—the Kœnig Wilhelm, a new Prussian iron-clad—and the results of the engines of Messrs. Maudslay, Sons and Field, builders of equal renown.

This vessel is 372 ft. 4 in. long over all, and 355 ft. 10 in. between perpendiculars, with 60 ft. beam; being 30 ft. 10 in. longer and 1 ft. broader than the Hercules, while her tonnage is 5,938¾ tons, being nearly 705 tons in excess of that of the last named vessel. She is provided with an armored battery commencing 42 ft. aft of the fore perpendicular and extending for a length of 232 ft. on the main deck, this battery being protected at the sides with 8 in. armor plates, and at the ends by plates 6 in. and 5½ in. thick. Besides this main battery there is an after battery protected with 6 in. plates, and having a port pointing directly astern; and also armor plated bulkheads on the upper deck. At the water line the Kœnig Wilhelm is protected by a belt

* Van Nostrand's Magazine, Vol. I, No. 3, p. 204.

of armor plating of which the lower edge is 6 ft. 8 in. below the water line amidships and a little less forward, whilst under the counter it rises considerably. The lower strake of this belt is composed of plates 7 in. thick amidships and tapering to 5 in. thick at the extremities, while the remainder consists of plates 8 in. thick amidships, tapering to 6 in. fore and aft. From the particulars we have just given it will be seen that the Kœnig Wilhelm is less heavily plated at the water line than the Hercules, while over the upper part or battery the armor is slightly heavier than that of the latter vessel. The port sills of the Kœnig Wilhelm are 10 ft. above the water line amidships, while those of the Hercules are 11 ft.; and there can be no doubt that the additional free board possessed by the latter vessel would prove of great advantage to her in the event of an action in rough water.

The Kœnig Wilhelm is fitted with a set of three-cylinder engines, by Messrs. Maudslay, Sons and Field, and we think that the performance of these engines during the recent trial must have given unqualified satisfaction to their makers and to all concerned. The cylinders are 95 in. in diameter, with 4 ft. 6 in. stroke, and during the trial they were run at a mean speed of 64 revolutions, and a maximum speed of 65.333 revolutions per minute, corresponding to piston speeds of 576 ft. and 588.117 ft. per minute respectively. The engines are fitted with surface condensers, exposing 17,250 square feet of surface; and steam is supplied by eight boilers, having 22,600 square feet of heating surface, and a fire-grate area of 890 square feet. Although rated at but 1,150 nominal horse power, the engines developed during the trial a mean indicated power of 8,345 horses, whilst during the running of the sixth mile the indicated power reached no less than 8,663.889 horse power, the highest result, so far as we are aware, ever obtained on shipboard with any engines, or under any circumstances; and one on which we think Messrs. Maudslay may fairly be congratulated. We give, on another page of the present number, engravings of the indicator diagrams taken during the sixth run, when the above power was developed, and to these and the particulars which accompany them we refer for more detailed information concerning the performance.

As we have already instituted a general comparison between the Kœnig Wilhelm and the Hercules, it may be interesting that we should similarly compare the engines of the two vessels, constructed as they have been by our two leading firms of marine engine builders. The principal results obtained during the respective trials were as follows:

	Hercules, engined by Penn.	Kœnig Wilhelm, engined by Maudslay.
Revolutions per min., max.	72	65.333
" " mean.	71.51	64
Piston speed in feet per min., max.,	648	588.117
" " mean,	643.59	576
Mean pressure of steam in boilers,	29.5 lb.	30.5 lb.
" " cylinders,	20.0 lb.	22.483 lb.
Average vacuum*	27.08 in	27.875 in
Nominal horse power	1200 H.P.	1150 H.P.
Mean indicated horse power	8528.75 H.P.	8345 H.P.
Maximum	?	8663.889 H.P.
Number of times the mean indicated exceeds the nominal horse power	7.106	7.256

The proportions of heating and condensing surface and fire-grate area to the power developed in the two sets of engines are as follows:

	Square feet per mean indicated horse power.	
	Hercules.	Kœnig Wilhelm.
Heating surface	2.7	2.9
Fire-grate area	0.106	0.108
Condensing surface	2.43	2.067

The draught of the Kœnig Wilhelm, on the occasion of her trial, was 24 ft. 4½ in. forward and 26 ft. 4½ in. aft, while her displacement was 9,542 tons, or 862 tons more than that of the Hercules during the corresponding trial. The area of immersed midship section, on the other hand, was 1,306 square feet, or 9 square feet less than that of the Hercules. For the particulars of the speed attained during the different runs, we must refer to page 135 of the present number, where these details are given, and we need only state here that the true mean speed, as determined by the "mean of means," was 14.499 knots against the speed of 14.691 knots attained by the Hercules. The coefficients given by the respective full power trials of the two vessels are as follows:

	Hercules.	Kœnig Wilhelm.
$\frac{\text{Speed}^3 \times \text{mid. sec.}}{\text{Ind. H.P.}}$	488	477
$\frac{\text{Speed}^3 \times \text{disp.}^{\frac{2}{3}}}{\text{Ind. H.P.}}$	157	164.3

It is, we think, unnecessary that we should comment upon the facts we have laid before our readers, as the remarks which we have on previous occasions made concerning the

* The weather barometer stood at 30.2 in. on the occasion of the trial of the Hercules, and 30.4 in. on that of the Kœnig Wilhelm.

Hercules will apply almost equally well to the Kœnig Wilhelm. This being the case, we need only say that we consider that to Mr. Reed is due the credit of having produced in these vessels the two finest ironclads afloat; and while we cannot but congratulate the Prussians on the possession of the Kœnig Wilhelm, we still more congratulate ourselves on the possession, in the Hercules, of a vessel which we believe to be, in many respects, her decided superior.

NEW ENGLISH LOCOMOTIVES.

In reviewing the late locomotive practice in England, "The Engineer" says that little or nothing has been done that was not done before. The relative merits of inside and outside cylinders remain in dispute. On the Great Eastern system, where Mr. Sinclair employed outside cylinders solely, Mr. Johnson, his successor, is building nothing but inside cylinders, while Mr. Adams, of the North London Railway, who built only inside cylinder engines, is now using outside cylinders. We mention these facts simply to illustrate the diversity of opinion which exists all over the kingdom on this point. So long as cylinders can be kept down to a diameter of about 16 in. the advantage seems to be with the inside type. The 4 ft. 8½ in. guage is too narrow for cylinders of larger diameter, unless the valve boxes are pushed out of their legitimate place, or the valves are left unbalanced.

The following are the particulars of some new standard engines:

FOUR WHEEL COUPLED LOCOMOTIVE,

built for the Great Southern and Western Railway of Ireland at the Company's works at Inchicore, Dublin, from the designs of Mr. A. M'Donnell, the locomotive superintendent of the line. This engine, although possessing no striking peculiarities, is yet well worthy of attention as a good example of a passenger locomotive for the 5 ft. 3 in. gauge. The engine is simple in construction, and ample bearing surfaces are provided for all working parts; whilst advantage has been taken of the width of the gauge to obtain a good large fire-box. The guide-bars, piston-rods, axles, axle-box guides and axle-boxes are of steel. The principal dimensions of the engine are as follows:

Boiler.	ft.	in.
Diameter of barrel inside smallest plate	4	0
Length of barrel	9	7
Length of fire-box casing	5	1
Length of inside fire-box at bottom	4	6
Width of inside fire-box at bottom	3	11
Height of inside fire-box at front	5	4¼
Height of inside fire-box at back	4	8¼
(All dimensions of inside fire-box are inside dimensions.)		
Thickness of barrel and fire-box casing plates	0	0½
Thickness of smoke-box tube plate	0	0¾
Number of tubes 174		
Length of tubes between tube-plates	9	10½
Diameter of tubes outside tube-plates	0	2

Heating Surface.	sq. ft.
Tubes (outside)	887.7
Fire-box	95.45
Total	993.15
Fire-grate area	17.6

Wheels and Axles.	ft.	in.
Diameter of driving wheel	6	6
Diameter of trailing wheel	6	0
Diameter of leading wheel	4	0
Distance between centers of leading and driving wheels	7	0
Distance between centers of driving and trailing wheels	7	9
Total wheel base	14	9

Cylinders.		
Diameter	1	4
Stroke	1	10
Distance apart from center to center	2	6½
Distance apart of frames	4	7

Weight of Engine. Empty:	tons.	cwt.	qr.
On leading wheels	9	5	0
On driving wheels	10	4	0
On trailing wheels	9	17	0
Total	29	6	0
In working order:	tons.	cwt.	qr.
On leading wheels	10	5	0
On driving wheels	11	1	0
On trailing wheels	11	1	0
Total	32	7	0

Mr. M'Donnell, we may mention, is now building for his line two double-bogie engines on Mr. Fairlie's plan, these engines having boilers and general details similar to those of the locomotive we illustrate.

SIX COUPLED TANK LOCOMOTIVES,

from the designs of Mr. Samuel Johnson, by Messrs. Ruston, Proctor and Co., of Lincoln, for the Great Eastern Railway. These engines are intended more especially for shunting purposes, for which they are excellently adapted. The cylinders, which are inside, are placed at an inclination of 1 in 10, this being just sufficient to enable the

guide-bars to be kept clear of the leading axle. The water is carried in a pair of wing tanks, and the fuel in a coal box at the back of the foot-plate, a cast-iron balance weight being placed beneath the latter to increase the weight on the hind wheels. The leading and driving springs are arranged above the axle-boxes in the ordinary way; but at the trailing end the weight is carried by a transverse spring placed behind the fire-box. In some six-coupled goods engines, with tenders, recently built from Mr. Johnson's designs, a transverse spring is also used at the hind end, whilst the leading and driving springs are connected by compensating beams, so the engines are carried on three points, the transverse spring of course acting as a compensating beam between the two bearings of the trailing axle. In the construction of these engines steel has been largely employed, the horn-blocks, slide-bars, piston-rods, crank-pins and tyres being all of Messrs. Vickers, Sons and Co.'s crucible steel. The barrel of the boiler is made of two plates, butt-jointed above the water line. The principal dimensions of the engines are as follows:

Cylinders.	ft.	in.
Diameter	1	4
Stroke	1	10
Distance apart from center to center	2	4
Length of ports	1	2
Width of exhaust ports	0	3
Width of steam	0	1¼
Width of bars	0	1
Distance from center of driving axle to center of exhaust port	8	10

Working Gear.		
Length of connecting rods between centers,	5	6
Diameter of bearing at large end	0	7
Length of bearing at large end	0	4
Diameter of bearing at small end	0	3
Length of bearing at small end	0	3
Width of guide bars (double)	0	2¾
Length of crosshead blocks	0	9
Diameter of piston rods	0	2¾
Diameter of valve spindles	0	1¾
Distance between centers of valve spindles,	0	4

Boiler.		
Diameter of barrel (inside)	3	9
Length of barrel (inside)	9	1
Length of fire-box casing (outside)	4	4¾
Width of fire-box casing	3	11
Depth at front below center line of boiler,	4	5¼
Length of inside fire-box at top	3	8
Length of inside fire-box at bottom	3	9
Width of inside fire-box at bottom	3	4
Height of inside fire-box at front	5	0
Number of tubes	124	
Diameter of tubes (outside)	0	2
Length of tubes between tube-plates	9	4 1/16
Diameter of blast nozzle	0	4¾

	ft.	in.
Diameter of chimney at top	1	3
Diameter of chimney at bottom	1	4

Heating Surface.	sq. ft.
Fire-box	70.8
Tubes	608.2
Total	679.0
Fire-grate area	12.5

Tanks.	ft.	in.
Length of side tanks	10	0
Height of side tanks	4	3¼
Width of side tanks at widest part	1	6
Contents of tanks 778 gallons.		
Length of coal box	2	0
Width of coal box	7	3¾

Wheels and Axles.		
Diameter of wheels	4	0
Distance between centers of leading and driving wheels	6	9
Distance between centers of driving and trailing wheels	6	9
Total wheel base	13	6

Bearings of Driving Axles.		
Length	0	7
Diameter	0	6¾
Distance apart from center to center	3	11¼
Diameter of axle between cranks	0	6¾

Bearings of Leading and Trailing Axles.		
Length	0	6¾
Diameter at center	0	6
Diameter at ends	0	7
Distance between centers of bearings of leading axle	3	11
Distance between centers of bearings of trailing axles	3	10
Diameter of leading and trailing axles at centers	0	6

Frames.		
Length inside buffer beams	22	6
Distance apart	4	1
Thickness	0	1¼
Depth (extreme)	2	7¼
Width over footplate at leading end	7	7
Width over footplate at trailing end	8	4

The weight of these engines is about 35 tons in working order, and they will exert a tractive force, less the internal resistances, of 117.3 lb. for each pound of effective pressure per square inch on the pistons. Thus with a mean effective pressure of 98 lb. per square inch they would exert a tractive force of about 11,500 lb. The boiler is worked at a pressure of 140 lb. per square inch, and is fed by a pair of injectors.

The engines we have described are, as we have said, well adapted for the work for which they are intended; and we understand that their performance has proved exceedingly satisfactory.

STEEL RAILS.

STANDARD PATTERNS ILLUSTRATED.

The sections of rails shown on the opposite page, embrace some of the best patterns, of various weights. The engravings (excepting fig. 3) are half size, and are made accurately to scale. The patterns are as follows :

FIG. 1.—65 *lb. Erie Rail.*—Of this pattern, some 1,000 tons had been made, on a large order, for the Erie road, by Messrs. John A. Griswold & Co., Troy, up to October last, when the converting works were destroyed by fire.

FIG. 2.—56 *lb. Penn. Railroad Pattern.*—This rail was designed by Mr. J. Edgar Thompson, President of the Pennsylvania Railroad, but a heavier pattern (fig. 4) has thus far been adopted on that line. Of the 56 lb. pattern, the Pennsylvania Steel Company have made some thousand tons for various roads—the Pittsburg, Fort Wayne and Chicago; the Michigan Southern, &c. Messrs. John A. Griswold & Co. have made about the same quantity of the same pattern for the Chicago and Northwestern, Rensselaer and Saratoga, and other lines. This may be called a favorite pattern. It is high enough to be fished to advantage, and well shaped for this purpose.

FIG. 3.—80 *lb. Paris and Lyons Railway.*—This pattern is specially intended for fishing, though we consider the required angle of the fish plate bearing too great; too great a strain would be brought upon the bolts. The rail below it (fig. 5) is much better in this regard. We think a wider head would also be preferable. But the base is very wide—5$\frac{1}{8}$ in., and affords an excellent bearing on the sleepers. The rails are 19 ft. 8$\frac{1}{4}$ in. long each. Their ends are unsupported, the distance between the sleepers, between which the joint is situated, being 23$\frac{3}{4}$ in. The sleepers next are at a distance of 2 ft. 3$\frac{1}{2}$ in., and the others of 2 ft. 7$\frac{1}{2}$ in. This gives eight sleepers per rail. The sleepers are made of ordinary, not of hard, sorts of wood. The dimensions of sleepers are: length, 8 ft. 6 in. to 9 ft. 2 in.; breadth, 7$\frac{7}{8}$ in.; height or thickness between, 5$\frac{5}{8}$ in. to 6$\frac{1}{4}$ in., according to the nature of the wood. On the Northern Railway of France the rails are 5 in. deep, 4$\frac{1}{8}$ in. wide at the side, with web $\frac{11}{16}$ in. thick, and they weigh 76 lb. per yard. The Bessemer works at Terre Noire are manufacturing the rails above described for the Lyons Railway.

FIG. 4.—67 *lb. Pennsylvania Railroad Pattern.*—This is the standard pattern on this line, for both steel and iron. Not less than 10,000 tons of steel rails from this pattern, about half of them having been made by the Pennsylvania Steel Company at Harrisburg, are in use. The shape of the head might be slightly improved for fishing, but altogether, it is an excellent pattern.

FIG. 5.—*The* 56 *lb. "Ashbel Welch" Rail.*—Mr. Ashbel Welch, the President and Engineer of the combined Camden and Amboy and New Jersey Companies, long ago determined to get the maximum service out of the new material. Instead of following the proportions adopted for iron, he made a pattern specially adapted to the greater strength of steel. His first pattern was still thinner in the flange than the present one, and although he expected to meet the views of rail makers a little more closely, in the end, be determined to test the capacity of steel to roll into such thin shapes, and its capacity to stand the service when rolled.—So he told the rail makers that they must make his pattern or none. John Brown & Co. at length undertook it, and found less difficulty than they had expected. The rails were put down where the service was hardest on the Camden and Amboy line, and stood perfectly. But upon the representations of rail makers that such very thin flanges would cost more—there being more "wasters"—and that they would not be as strong in proportion to their metal as thicker ones, on account of their cooling and rolling cold while the rest was hot, Mr. Welch changed the pattern to that shown in fig. 5. This is not a pattern that red short steel, or roughly cast ingots, will roll into with any success, but the Pennsylvania Steel Company have just rolled 500 tons of it for the Philadelphia, Wilmington and Baltimore line, without more than the usual number of bad flanges—in fact, without any difficulty to speak of. This is a very carefully studied and, in an engineering point of view, excellent pattern, but railway companies have thus far selected the other rail of the same weight (fig. 2) in the majority of cases.

FIG. 6.—67 *lb. Erie Steel-headed Rail.*—This is the latest Erie pattern. The Trenton Iron Company are now rolling this pattern, on an order, the extent of which we shall not undertake to mention. They are producing excellent rails with heads made either of puddled steel, or of steel made by the Siemens-Martin process.

FIG. 1.

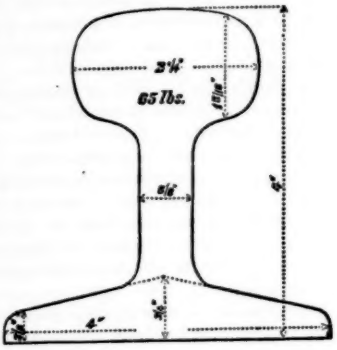


FIG. 2.

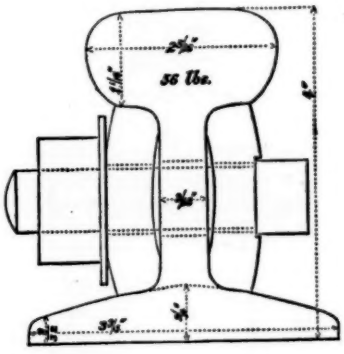


FIG. 3.

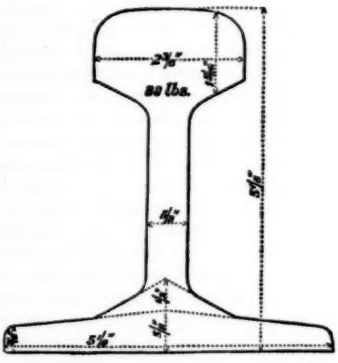


FIG. 4.

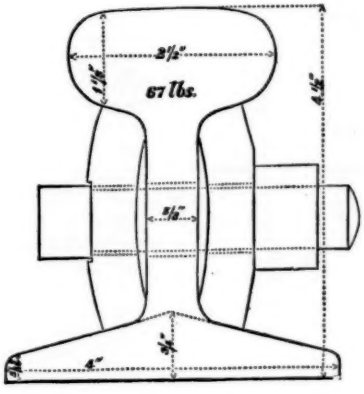


FIG. 5.

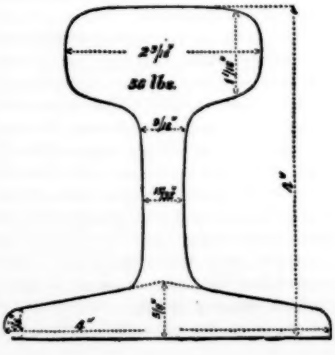
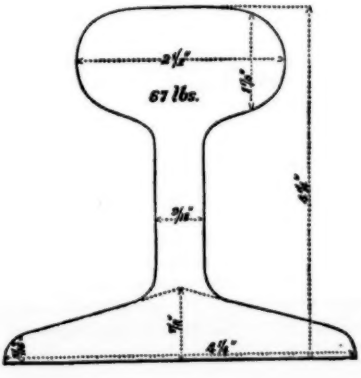
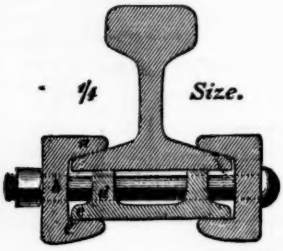


FIG. 6.



REEVES' NEW JOINT FASTENING.

FIG. 1.



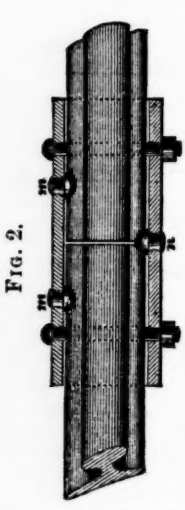


FIG. 2.

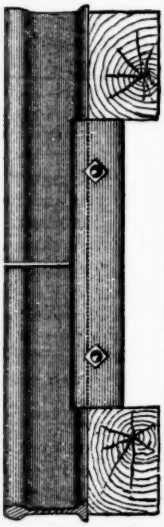


FIG. 3.

The most approved form of this excellent device, to which we have referred on other occasions, is illustrated by the above cuts. It should be explained that stops *n* and *m*, fig. 2, are not used on both sides of the rail. The single stop *n* requiring only the corner of the flange to be cut off, has been heretofore used. Mr. Reeves, however, prefers the two stops *m m*.

The advantages of this joint fastening, especially for steel rails, are very clearly set forth by the letter of Mr. Hinckley, President of the Philadelphia, Wilmington and Baltimore Railway (see page 357). The engineer of this line reports that only two nuts in the 8,000 in use have been found loose, and that only one clamp has been broken, and this by driving it with a sledge upon the rail. The motion of a train over these joints is noticed to be very smooth, and instead of the clatter observable in case of a common chair, or any loose joint, a peculiar ringing noise is heard, resembling the sound of a solid piece of metal when struck. This is the best evidence of the continuity produced by a tight joint.

The elasticity of the joint is another noticeable feature. There is nothing about it representing an anvil. The points *a*, *c*, *e*, and also the edge of the flange, may all yield very slightly. That they do so yield is proved by the fact that no wear is observed between the parts in contact. Wear always occurs between rigid parts similarly situated, as in case of the old-fashioned compound rails.

The weight of this fastening complete, with clamps 14 in. long, is 30 lbs. Its cost is $2.

THE RENSSELAER POLYTECHNIC INSTITUTE—This scientific school is one of oldest, if not itself the oldest, in the country; and certainly no other American institution has furnished so many successful engineers. The course of study is very severe; and young men who graduate and receive their degrees at Troy are qualified to commence brilliant and useful careers.

It seems strange to us that for so many years, during which other institutions, no whit more deserving of support, have been munificently endowed, this one has been left entirely dependent upon the fees of the students. As a consequence those rates are comparatively high. Two hundred dollars a year is, we are informed, the present charge for tuition; and it is not found to be more than sufficient for the maintenance of an efficient system of instruction and practical training. But it undoubtedly operates to prevent many from attendance who would gladly purchase, at a lower rate, the benefits of a scientific education.

In addition to its age and general excellence, the Rensselaer Institute has two special claims upon the public. The first lies in the fact that in the destruction of its buildings by fire, a few years ago, its scientific resources were sadly crippled. It is true that indomitable energy and perseverance have done much to repair the damage. A new and handsome building upon the steep hill-side overlooking the city of Troy, and the beautiful and well-appointed Winslow laboratory close by, bear witness to the vitality which inheres in this enterprise, and give promise of its extended activity and

influence in the future. The Institute is gradually replacing its lost library, apparatus and collections. It is slowly recovering from the disaster which befell it; and there is no doubt of its ultimate and complete success on a larger scale and by a higher standard than measured its ancient glory. But this recovery, however sure, ought to be quick, not slow. Whatever money can do to annihilate time should be done.

The other claim of this institution upon the public is the provision which has been made in its courses for the education of mining engineers and metallurgists. Durring a recent visit we were much pleased with the progress already achieved in this department, and the judicious plans matured for the future. As our readers are aware, Prof. G. W. Maynard occupies the chair of mining and metallurgy.

When it shall at last come to pass that our American, like the European mining schools, shall be distinguished, each in some special branch of the arts related to mining, we think Rensselaer will be likely to represent especially the metallurgy of iron, a branch so important as to form in some foreign schools, as, for instance, that of Losben, the chief attraction for students, and the main portion of the instruction imparted.

Troy is the site of the far-famed Burden iron furnaces and rolling mill, as well as the scarcely less celebrated Bessemer Steel Works of Messrs. John A. Griswold & Co. The latter were seriously injured—we may almost say destroyed—by fire a few months ago, but are now being rebuilt under experienced management. They can produce at present but eight tons of Bessemer steel daily; but the works now in progress will increase this capacity to upwards of fifty tons. The innumerable puddling furnaces and other iron-metallurgical works in Troy, added to the two establishments we have mentioned, are so many arguments for the importance of maintaining with ample power, in the midst of an industry so vast and profitable, an institution like the Rensselaer, to serve as a storehouse for the preservation and an exchange for the communication of a great number of valuable observations concerning the latest processes of the metallurgy of iron. Moreover some provision might be made for giving certain courses of instruction by public lectures or otherwise to the workmen themselves. Even a common laborer accomplishes all the more and all the better for understanding what he is doing.

A course of popular and scientific lectures is in progress for the aid of the Institute library. We sincerely hope it may succeed; but this is too slow a means to achieve the desired result. There is little merit in urging other men to give their money for the public good; but we think ourselves justified by the circumstances in remarking that the rich men of Troy, and all the graduates of the institution, or their friends, should unite to raise for the school a large permanent endowment. Such assistance, rendered at the right moment, *i. e.*, very soon, would have a marvelous effect in stimulating the activity and doubling the beneficent influence of the Institute. Who endows the Rensselaer school?—*American Journal of Mining.*

ENGLISH ORDNANCE EXPERIMENTS.

EFFECT OF CANNONADING A CASEMATE, UPON SHELLS STORED WITHIN IT.

From "Engineering."

On February 11th, an experiment was conducted at Shoeburyness, with the view of ascertaining the probable effect which would be produced by a cannonade upon a casemate within which loaded shells were stored, and also the extent of damage which the explosion of one shell would produce upon the surrounding ones. For this purpose 50 live common shells, for the nine in. rifled gun, were disposed with the area of an armor-plated casemate. Each of these shells contained a bursting charge of eighteen lb., in all 900 lb. of powder. The floor of the casemate is about 20 square feet, the height to the crown of the brick-turned roof being about twelve ft. The opening at the west end of the casemate was closed up by two seven in. thick iron plates, eight ft. six in. by four superficial, and weighing about five tons each. The opening at the east end was closed by several large sheets of iron ¾ in. skin and the huge rope manlet. The rears of the two casemates were left perfectly open. The main mass of the shells, 42 in number, and containing 798 lb. of powder, were laid on their sides, and piled in two rows, with their plugged ends pointing laterally outwards. For the convenience of aiming the gun through the porthole, the pile of shells was raised two ft. nine in. above the floor on a platform about eight square feet, composed of bags of sand and concrete, packing-boxes,

and loose earth, covered over with an old deal target. Four shells were placed against each wall of the casemate at the side, about six ft. or seven ft. away from the pile.

The nine in. Woolwich muzzle-loading rifled gun was placed at 70 yards in front of the casemate, and laid at the center of the pile, as seen through the open port. The charge was the full battering charge of 43 lb. of large grained rifle powder, and the Palliser shell weighed, empty, 246 lb., and contained a bursting charge of five lb. twelve oz. The gun was fired by the magneto-electric apparatus, and the result of the explosion on the exterior of the casemate was to shake the massive brickwork and masonry of the casemate, to widen and increase the cracks and fissures made by the former firing against the armor, and to open new ones. Inside the structure the wreck was terrible to look at, the whole floor of the casemate being covered with the *debris* of concrete, earth, fallen bricks, fragments of wood, and exploded shells, commingled with entire shells which had not been injured, and which were thrown about in all directions, one 28 yards away on the open beach to the rear. On closer examination it was found that nineteen shells had been exploded, and that 31 had been hurled violently away without damage. Fearful, therefore, as the destruction looked, it must be remembered that the experiment was a thoroughly crucial one, and that the shells had really shown themselves as safe magazines for powder as could possibly be expected.

In the interior of the casemate itself there was first the concrete and earth platform; the floor was covered to the depth of some inches with the *debris*. Two shells lay close to the front, one on each side of the port; another on the sill of the west opening, the four which were stood erect along the rear part of the west wall being all blown aslant, and two others out of the pile lying aslant likewise, close to the wall beside them. The large iron skin (6 ft. 6 in. by 6ft. 6 in., 3¾ in.) at the back of the shield buttress, was blown down.

To the seaward, within seven ft. of the casemate, there were ten unexploded shells, one had a fragment broken from its rear end six in. in length and one in. wide. Sixteen feet seaward of this again, lay two whole shells on the west side, and at fourteen ft. one on the east side; and still farther seaward, 28 yards away from the casemate, lay the most distant of the shells cast away from the pile by the explosion. Thence to the water's edge, some 70 paces, the ground was strewed with fragments of shells and broken wood. Outside the eastern opening the two seven in. plates were blown away from six to twelve ft., two whole shells were lying among the *debris* of sand bags; 30 ft. from the casemate a third whole shell was found perfectly uninjured.

The front of the pile of shells before the firing was 21 ft. from the face of the port-hole; the quantity of powder in the shells exploded was 342 lb. The attacking shell would seem to have driven right through the two lowest tiers of piled shells, say twelve and ten respectively, and, in total, 22, exploding nineteen, and knocking the three rear ones away.

PRACTICAL INSTRUCTION IN ENGINEERING.—The engineering course at Lafayette College has some features which are worthy of the attention of all our technical schools. While the general curriculum, embracing four years, is designed to give the engineer all the culture of a thorough college course in addition to the special instruction for his profession, this class is organized as an engineering corps, and goes through all the necessary operations for the construction of a railroad from Easton to some selected terminus. This work includes reconnoissance, running preliminary lines, fixing the final location of the road with the most favorable attainable grades and curves, the construction of maps, profiles, cross sections, &c., the computation of excavation, masonry, &c. The field work and office work, including drafting and calculation, are performed under the immediate direction of Professor Walling, who accompanies the corps and directs their investigations. The bridges, tunnels and depots, are also located, and all necessary plans and calculations are made, with a discussion of the principles involved. In short, the whole work of a division engineer is performed, so that the graduate has not only scientific theory, but actual practice, and is ready at once to assume important and responsible positions.

We may add that the technical courses at Lafayette have all been recently enlarged and greatly improved. Mr. Pardee, of Hazleton, Pa., has contributed for this object the munificent sum of two hundred thousand dollars, making, with the generous donations of other friends of the institution, nearly half a million of dollars lately added to the college funds.

PAPERS ON CONSTRUCTION.

No. I.

By Lieut. C. E. Dutton.

The determination of the strength of materials involves an investigation into the following conditions: (1) the nature of the material; (2) the stress to which the various pieces are subject; (3) their shapes and dimensions; (4) the manner of their support. Although other conditions must be frequently considered, the foregoing are universal.

It is not proposed, in these papers, to discuss the more general properties of material separately, since these are in the main well understood. Particular discussions, however, in connection with other conditions will be given in the proper places.

The strains to which material is subjected may be reduced to five kinds: (1) tension, (2) compression, (3) transverse strain, (4) shearing, (5) torsion. To these might be added a sixth, viz; those internal strains resulting from the peculiar molecular constitution of the material when subject to certain forces acting upon molecules or atoms. This kind of strain, however, should more properly be considered in a discussion of the nature of materials.

1. A body is subject to a strain of *tension* when two forces are acting upon it in opposite directions, and *from* each other. A body fixed at one end, and having a tensile force applied to the other, resists rupture by the cohesive force inherent in the molecules which constitute it. It is generally assumed that, in a body nearly homogeneous, each molecule opposes to a given force a resistance nearly equal to that of every other molecule. Although this assumption is only approximately true, it is necessary to make it, since it is the only way in which we reduce the phenomena of resistance of materials to system, and subject them to analysis.

It will be safe enough to assume, whatever may be the resistance of any molecule to rupture by a given force, that their average resistance is a constant quantity. On this assumption the total resistance of a body to rupture by tension, at a given section, will be the sum of the resistances of all the molecules of that section. The number of these is directly proportional to the area of that section, and hence the resistance will always be proportional to that area.

This proposition must be qualified in particular cases by the condition that the stress be applied equally, and at the same time, to every portion of that area. In the case of a cylindrical rod, or bar, if the force be applied at the convex surface of the cylinder only, it is evident that a portion of the surface will be strained more than the central or axial portions, and the cylinder will yield to a force less than that due to the area of section, by the rupture, first, of the surface portions, and then of portions successively nearer the axis.

2. All materials under tension are elongated. The elongation becomes permanent when the tension is great, and increases in a higher ratio than the force applied. A restoration takes place when the force is removed; but it is only partial, except in cases where the force is slight compared with the ultimate strength of the material. Continuous tension, or tension repeatedly applied, even within the limits of elasticity, will produce a set, and if sufficiently continued will ultimately produce rupture, or seriously impair the strength. A slight diminution takes place in the permanent set when the body is allowed a protracted rest. Within the limits of tension to which sound practice would subject any material, it will give a closely approximate result if we make the extension proportionate to the force applied. It is also in direct ratio to the length of the piece, and in an inverse ratio to the area of section; whence the following formula: $e = \frac{t\,l}{A} m$, in which $e =$ the extension, $t =$ the strain, $l =$ the length of a piece of uniform section, $A =$ the area of that section, and $m =$ a co-efficient to be determined by experiment.

In most equations relating to the strength of materials, experimental co-efficients necessarily enter. These co-efficients are dependent for their value upon the properties of the materials under discussion, as determined by direct experiment. Thus, in an expression of the tensile strength or resistance to compression, it would indicate the tenacity or resistance per square inch: in an equation of transverse strength it may express the transverse strength of a piece of material one foot long and one inch deep. In general it may be said to express the value or amount of a particular property, found experimentally in a piece of the material under discussion having given dimensions.

For a moderate stress of tension the elongation of a bar is approximately a

measure of the strain. The *modulus* of *elasticity* for extension (which is a method of expressing the resistance to extension) is determined by the amount which a bar of given size can be extended by a given weight. This resistance will evidently vary directly as the length and stress, and inversely as the extension. Let l be the length, s the stress, and e the extension; then $M = \frac{l\,s}{e}$. This expresses merely the intensity of resistance within the limit of elasticity, and does not hold good beyond it.

3. In practice it is found necessary to divide the theoretical strength of all materials by a divisor varying with the material and kind of strain, for the working strength of all materials intended for continued use is seriously affected by various causes which cannot be calculated, except as average results of experience. In tensile strains the safe load is usually estimated at from one-tenth to one-fifth the theoretical strain. The divisor is called the "*factor of safety*. Since all estimates for strains, of whatever kind, require modification by a suitable factor of safety, the relations of "breaking loads," "proof loads," and "working loads," to each other will be specially treated of hereafter.

4. *Resistance to crushing.*—Crushing is an operation of considerable complexity. In practice materials seldom yield to direct compression. It is only when pillars of considerable length are subjected to such a stress that rupture occurs, and then it is produced by flexure, and almost never by a collapse of the material itself. The strength of a column, therefore, will depend both upon its resistance to crushing and its rigidity. Mr. E. Hodgkinson, of Manchester, has investigated this subject experimentally with great ability, and his results have become standard among engineers.

Rupture by compression may take place in the following modes: (1) by splitting into laminated or prismatic fragments, like hard wood well seasoned; (2) by bulging, lateral swelling, or spreading, which is characteristic of tough, ductile material like wrought iron. In both these cases the resistance is decidedly less than the tenacity, and takes place gradually. (3) By sliding, or oblique shearing, which occurs in substances of a granular or crystalline texture like cast iron and stone. In such cases wedges or cones are forced out laterally. (4) By buckling, which takes place in beams made of flexible material, and longer than those which yield by bulging.

The formulæ obtained by Mr. Hodgkinson are as follows:

Let D = the external diameter or side of square in inches.
Let d = the interior diameter of hollow column in inches.
Let l = the length in feet.
Let w = the breaking weight in tons (2000 lbs.)

Solid cylindrical column cast iron, ...	$w = 49.4\frac{D^{3.55}}{l^{1.7}}$
Hollow cylindrical column cast iron, . .	$w = 49.6\frac{D^{3.55}-d^{3.55}}{l^{1.7}}$
Solid cylindrical column wrought iron, . . .	$w = 149.7\frac{D^{3.55}}{l^2}$
Solid square pillar of oak, ...	$w = 12.2\frac{D^4}{l^2}$

The foregoing formulæ are for columns with flat ends whose lengths are from 30 to 60 times their diameters, and which yield wholly by bending. When the columns are shorter than these proportions, and are longer than five or six times their diameter, the rule is as follows: first, find the value of w by one of the preceding formulæ; then let c = the crushing strength per square inch of the material under discussion, then

$$\text{breaking weight} = \frac{c}{1 + .75\frac{c}{w}}.$$

The following formula is deduced by Mr. Lewis Gordon from Hodgkinson's experiments for a column of *any* section.

Let w = breaking weight in lbs., a = sectional area in inches, l = length, d = the least external diameter, c = a constant dependent upon the crushing strength per sq. in. of the material, e = a constant dependent upon resistance to flexure; then, approximately,

$$w = \frac{c\,a}{1 + e\left(\frac{l}{d}\right)^2}.$$

The following are the values of c and e for iron pillars having flat ends:

	Values of e.
Wrought iron.	$\frac{1}{3000}$
Cast iron.	$\frac{1}{4000}$

Values of c.	Breaking load.	Proof load.	Working load.
Wrought iron.	36,000	18,000	6,000 to 9,000
Cast iron.	80,000	26,700	13,300 to 20,000

In using the foregoing formula it will be necessary to use care in determining the ratio $\frac{l}{d}$. In wrought iron frame-work and machinery the bars which act as struts, in order that they may have sufficient stiffness, are made of various forms in cross section, well known as "angle iron," "channel iron," "T-iron," and "double T-iron," etc. In each of these forms the line to be considered as d is the diameter in that direction in which the bar is most flexible, of a triangle or rectangle circumscribed about its section.

The ultimate resistance of wrought iron tubes, composed of plate iron riveted to angle irons at the corners, was stated by Mr. Fairbains to be 27,000 lbs. per square inch of section of iron. This is in cases where the ratio of length to diameter exceeds 30. The yielding is always by buckling. But when a number of these tubes are placed side by side, the resistance becomes 33,000 or 36,000 lbs. The same co-efficients apply also to cylindrical tubes. (Rankine.)

5. In cases where the center of pressure does not coincide with the axis of the column, it is evident that a greater strain will be thrown on one side than on the other, and the load which the column will sustain will therefore be diminished in the ratio in which the mean intensity of the stress is less than the maximum intensity. To find that ratio it is sufficiently near the truth to assume that the stress is uniformly varying.

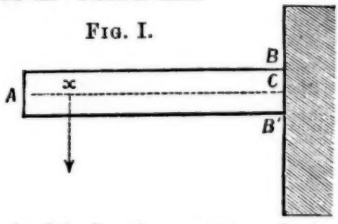
Let x= the greatest deviation of the center of pressure from the center of figure in any cross section; that is, the greatest deviation of the line of action of the load from the axis of the pillar. Let x' be the distance of the point of greatest stress from the axis of the pillar; that is, the same diameter of the pillar in the direction in which the load deviates from the axis.

Let I denote what is called the moment of inertia of the cross section of the pillar (a term which will be explained under the head of transverse strength); let S= the area of the transverse section in sq. inches, and let f= the resistance of the material to crushing in lbs. on the sq. inch. Then the crushing load is $P = \frac{f S}{1 + \frac{x x' S}{I}}$. The following are some of the values of $\frac{x' S}{I}$ in this formula. (Rankine.)

I. Rectangle $h\,b$; b neutral axis, ...	$\frac{6}{h}$
II. Square h^2	$\frac{6}{h}$
III. Ellipse; neutral axis b; other axis h, . . .	$\frac{8}{h}$
IV. Circle; diameter h, .	$\frac{8}{h}$
V. Hollow rectangle outside diameter $h\,b$; inside diam. $h'\,b'$; neutral axis b, ...	$\frac{6\,h\,(h\,b - h'b')}{h^3\,b - h'^3\,b'}$
VI. Hollow square $h^2 - h'^2$	$\frac{6h}{h^2 + h'^2}$
VII. Circular ring diameters h and h', . . .	$\frac{8\,h}{h^2 + h'^2}$

6. *Transverse Strength.*—A horizontal beam having one end fixed in a vertical wall, and subjected to stress in a direction perpendicular to its length, will be forced out of its normal shape and subjected to internal strains of a complex nature. If a weight act vertically downwards, the upper layers of the beam will be subjected to tension, and the lower layers to compression. There will be an intermediate layer where neither of these forces operates, and this is called the "*Neutral Axis.*"

FIG. I.



It is plain that the greatest tension occurs at the upper surface, and the greatest compression at the lower surface, and the amount of change in any layer is proportional to the distance of that layer from the neutral axis. The effect produced upon the beam by a given weight will obviously vary directly as the distance from the wall at which it is applied. If $A\,C$, Fig. I, be the neutral axis, then $A\,C\,B$ and $A\,C\,B'$ may be regarded as bent levers of which the arms $C\,B$ and $C\,B'$ are constant; and if the weight W be applied at the distance x, then the effect of W will vary as x. If W be multiplied by the distance at which it acts, the product will be what is called the "*Moment of the Weight;*" *i. e.*, the amount and efficiency of the force as determined by its "*leverage.*" When the weight is applied at a single point, then the moment of weight

$= Wx$. When it is distributed over a continuous length, it is plain that each point has a moment of its own, and that the whole moment will be equal to the sum of the moments of all the parts. Suppose the beam to be divided up into an indefinite number of equal parts, having the length dx; then the weight on each of these parts will be proportional to the length of the part, and equal to the intensity of the weight multiplied by this length. The intensity of weight for a unit of length is equal to the whole weight divided by the whole distance over which it is distributed, and in case the beam is uniformly loaded over its whole length, the intensity will be $\frac{W}{l}$ and the weight upon $dx = \frac{W\,dx}{l}$. The moment of this weight will be $\frac{W}{l}.x\,dx$, in which expression $\frac{W}{l}$ is a constant quantity. The entire moment therefore (making $x = l$) is

$$M = \frac{W}{l}\int x\,dx = \frac{W}{2\,l}\cdot\tfrac{1}{2}x^2 = \frac{Wl}{2}.$$

The moment of a uniformly distributed load is therefore one-half the moment of the same load acting at the free end. In case the load is uniformly distributed over a part of the length $= a$ between the points x and x', the above expression becomes

$$M = \frac{W}{a}\int_{x'}^{x} x\,dx = \frac{W}{a}\tfrac{1}{2}(x^2 - x'^2).$$

Making $x = l$ and $x' = l - a$ the above becomes

$$M = \frac{W}{a}\tfrac{1}{2}\,(l^2 - (l-a)^2) = W\left(l - \frac{a}{2}\right).$$

7. When a beam is supported at both ends, and a weight applied between the supports, we may consider the reaction of these supports as forces acting upwards upon the free ends of a beam supported in the middle; or the beam may be considered as a lever of the third order, where the power is applied between the extremities. Adopting for the present the latter view, and making $l =$ the distance between supports, and $x =$ the distance from A of the point of application of the weight, then the pressure upon B, or what is the same thing, the reaction of B will be inversely as the length, and directly as the weight, and the distance from A; *i. e.*, $P = \frac{Wx}{l}$. Similarly, the pressure upon A will be inversely as the length, and directly as the weight, and the distance from B; *i.e.*, $P' = \frac{W(l-x)}{l}$. Adding these equations $P + P' = \frac{Wx}{l} + \frac{W(l-x)}{l} = W$, we find that the sum of the pressures upon the two supports is equal to the whole weight. The moment of reaction of the support B will be $= P(x-l) = \frac{Wx\,(l-x)}{l}$ and the moment of reaction of the support A also $= P'x = \frac{W(l-x)\,x}{l}$: therefore these two moments are always equal. Since, in every case $x + (l-x) = l$, the equation of moment becomes a maximum when $x = \frac{l}{2}$, and becomes zero when $x = o$, or $x = l$. Hence the moments of weight are greatest when the weight is in the middle of the beam, and are nothing when it is at either support. Making $x = \frac{l}{2}$, then $\frac{Wx\,(l-x)}{l} = \frac{1}{4}\,W\,l$, *i. e.*, the effect of a weight placed in the middle of a beam supported at both ends is one-fourth the effect of the same weight at the free end of a beam fixed at one end.

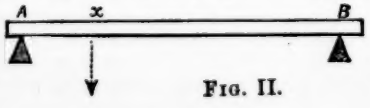
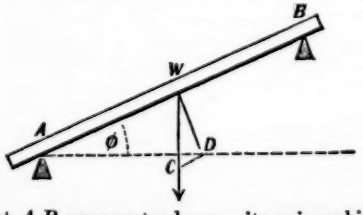


FIG. II.

In the case of a uniformly distributed load we may assume the supports to be forces acting upwards against a beam supported at the center by the weight. By referring to equation (1) it will be seen (bearing in mind that $x = \frac{1}{2}\,l$) that $M = \frac{1}{2}P\,(l-x) = \frac{\frac{1}{2}\,Wx\,(l-x)}{l} = \frac{1}{8}\,Wl$. Hence, a beam will support twice as great a load distributed uniformly as it will when the load acts at the center alone.

8. When the weight does not act perpendicularly to the length of the beam, the foregoing conditions are somewhat modified.

FIG. III.



Let $A\,B$ represent a beam—its axis making with the horizon an angle $= \phi$. Let the

weight act vertically, and let $W C$ represent the magnitude of the weight. Resolve $W C$ into two components, $W D$ and $D C$; the former perpendicular and the latter parallel to the axis of the beam. Then $D C$ is a force having no transverse effect, but is subject to the laws of longitudinal stress, while the component $W D$ represents the whole of the transverse effect of W. The relation of $W D$ to the whole load is expressed by the equation $W D = W \cos. \phi$, and the equation of moment becomes $M = \frac{W x (l-x) \cos. \phi}{l}$.

9. From the foregoing, therefore, we may deduce *the general principle, applicable to all cases of transverse strain, that the effect of a load upon a beam varies directly as the length of the beam.* It now remains to determine the relations of the load to the cross section. Reverting to Fig. I, it is apparent, assuming that $A\ C\ B$ and $A\ C\ B'$ are bent levers, that the intensity or effect of the resistance of any layer to extension or compression must vary as its distance from the neutral axis, because the leverage is proportional to that distance. But owing to the curvature of the beam the tendency to rupture or the strain is also directly proportional to that distance. These two forces are always equal and in opposition, up to the limit of elasticity either for compression or extension, and therefore hold the beam in stable equilibrium. Beyond that limit the action of these forces follows no known law. Our discussion, therefore, must be with reference to strains within that limit.

Let Fig. III represent the cross section of a rectangular beam, of which XX' is the neutral axis. Let l be any layer of very small thickness at the distance x from the neutral axis. Let t be the thickness of the layer, and s the intensity of the stress to which it is subjected. Let $b =$ the breadth of the beam. Since the intensity of the stress varies directly as its distance from the neutral axis, then $\frac{s}{x} = c$, a constant quantity. The amount of stress on the layer l will be expressed thus: $Q = s\ b\ t = c\ x\ b\ t$. If we assume l to be at the edge or surface of the beam, and divide the distance between it and the neutral axis into an indefinite number of layers of the thickness t, then the amount of stress on each layer may be expressed in the same way as that on l.

FIG. III.

Thus the amount of stress on the layer next to l will be $Q' = s'\ b\ t$, and on the next, $Q'' = s''\ b\ t$. The moments of these stresses, *i. e.*, the amounts multiplied by the distances from the neutral axis, will be $s\ b\ t\ x$, $s'\ b\ t\ (x-t)$, $s''\ b\ t\ (x-2)$, etc., and their sum will be equal to the moment of resistance of the entire portion of section under discussion.

$R = b\,t\{s\,x + s'(x-1) + s''(x-2) + s'''(x-3) \ldots\ldots\ldots + s^n\,(x-n)\}$. Now, $s = c\,x$, $s' = c(x-t)$, $s'' = c(x-2'')$ etc., and $t = \frac{x}{n}$ substituting these values in the foregoing equation

$$R = c\,b\,\frac{x}{n}\left\{x^2 + \left(x - \frac{x}{n}\right)^2 + \left(x - \frac{2\,x}{n}\right)^2 + \left(x - \frac{3\,x}{n}\right)^2 \ldots\ldots\ldots + \left(x - \frac{n\,x}{n}\right)^2\right\} =$$

$$c\,b\,\frac{x^3}{n}\left\{1 + \left(\frac{n-1}{n}\right)^2 + \left(\frac{n-2}{n}\right)^2 + \left(\frac{n-3}{n}\right)^2 \ldots\ldots\ldots + \left(\frac{n-n}{n}\right)^2\right\}.$$

The sum of the series contained in the brackets $= \frac{n}{3}$ therefore $R = c\,b\,\frac{x^3}{n} \times \frac{n}{3} = \frac{1}{3}\,c\,b\,x^3$.

Substituting for c its value $= \frac{s}{x}$

$$R = \frac{s}{x} \times \frac{b\,x^3}{3} = \tfrac{1}{3}\,s\,b\,x^2. \qquad (1)$$

Hence the resistance of a beam varies as the square of the depth.

The same result is obtained by direct integration, thus: making $t = dx$, then the moment of stress upon the differential layer $l = s\,b\,x\,d\,x = \frac{s}{x'} b\,x^2\,d\,x$. Then, since $\frac{s}{x'}$ is a constant, the whole moment of resistance becomes $= \frac{s}{x'} \int_o^{x'} b\,x^2\,d\,x = \frac{s}{x'} \times \frac{1}{3}\,b\,x^3$. Making $x' = x$ we have the same result as before.

The factor $\frac{1}{3}\,b\,x^3$ is termed the "moment of inertia" of the cross section. It is compounded of three factors, expressing as many relations: first, the intensity of resistance made by any particle of the section to a stress, which intensity varies directly as the distance from the neutral axis; second, the area, $b\,x$ of the section, or the number of particles which resist, and third, the distance or moment proper from the neutral axis at which the force acts. The factor s is termed the *modulus of rupture*, of working load, or of proof load, according as the one

or other of these stresses is in question. Its value must be determined experimentally in beams of each kind of material, and in general does not correspond exactly either to the modulus of rupture for tension or for compression, but has a special value peculiar to transverse stresses.

The foregoing applies to beams of rectangular section; for beams of any other form the expression must be correspondingly modified. The analysis given has been with respect to one side of the neutral axis. An equal amount of resistance of an opposite kind takes place on the other side. So long as s does not exceed the limit of elasticity, either for the compression or extension of the material, the moments on both sides the neutral axis will be equal, and we may assume that this axis passes through the center of gravity of the section. In the rectangular section, making $d = 2x$ the depth of the beam, and substituting, we have $R = \frac{s}{3x} \cdot b x^2 = \frac{1}{6} s b d^2$, and the moment of inertia becomes $\frac{1}{12} b d^3$.

10. In deducing from the foregoing the resistance of a beam having some other section, let $m =$ a factor depending upon the form of that section. Then the equation of resistance becomes $R = \frac{1}{6} m s b d^2$. The following table gives the values of m for several forms.

Form of Section.	$m =$
Circle $D =$ diam.....	$\frac{6\pi}{32} = 0.5892$
Ellipse	the same.
Hollow rectangle $b d - b' d'$	$1 - \frac{b' d'^3}{b d^3}$
Hollow circle.....	$\frac{6\pi}{32}\left(1 - \frac{d'^4}{d^4}\right)$
Hollow ellipse.....	$\frac{6\pi}{32}\left(1 - \frac{b' d'^3}{b d^3}\right)$
Isoceles triangle base $= d$...	$\frac{1}{4}$
I section where $b' =$ sum of the depths of channels..	same as hollow rectangle

11. Hence we draw the conclusion that the transverse resistance of a beam varies as the square of the depth. Having shown already that the resistance varies inversely as the length, it remains to consider the effect of the breadth. It is plain that if we divide a beam by a vertical plane parallel to the axis, the strength will be in no wise affected; the combined resistance of the sections being equal to that of the undivided beam. Therefore the beam will vary as the number of elementary sections into which we may conceive it to be divided, or, in other words, will vary directly as its breadth.

12. The strength also will be modified by the kind of material and its properties with reference particularly to its resistance to direct tension or crushing. If the resistance of the material to tension is greater than to compression, it will yield transversely by the buckling or collapse of the compressed surface. This is the case with wrought iron or wood. If the resistance to direct compression is greater, the yielding will be by the rupture of the extended or convex surface. In computing the effect, therefore, of the peculiar nature of any material, it will be necessary to ascertain, first, whether its tensile or compressive strength is the greater, and to assume the less of the two as the true strength. Knowing the modulus of rupture for direct tension and compression, we would be able to compute readily a theoretical transverse strength of a beam of given dimensions and material. Practically, however, such a computation would be in many cases valueless, because no material is perfectly homogeneous and free from internal strains, which are beyond the reach of mathematical investigation. A lack of homogeneity may not interfere with tolerably uniform results in experiments made upon the tensile strength of materials, because such defects are generally averaged throughout a mass, and the strain at every point is uniform. But the tension developed by a transverse stress is not uniform, but varies as its distance from the neutral axis, and a want of homogeneity in the extreme outer layer is sure to make itself apparent by yielding at the point where it is weakest. The use, therefore, of the constants which would be furnished by the moduli of elasticity is inadmissible. A much more reliable method, as already intimated, is to determine the resistance of beams of standard size to transverse stress for each kind of material, and adopt the results as co-efficients.

Nor is this the only error to which such a computation would be liable. It is found in practice that the value of a constant depending upon the nature of the material, is constant only for a given form of cross section. The same material, in beams of different cross sections, will offer an amount of resist-

ance which cannot be accounted for by the known relations of form to theoretical strength. It becomes necessary then to determine experimentally the value of each kind of material in beams of various cross sections before we can obtain an empirical constant which is to be depended on. Any other method of arriving at such values is always liable to a very material error.

Representing by m the value of this experimental constant, and having already determined the relations of the three dimensions—length, breadth and depth—we may now proceed to deduce general expressions for the relations of the load to the dimensions of the beam, within the limits of elasticity. In all cases the resistance, R must be equal to the tendency to rupture, N; and the expression

$$N = R$$

must be true for all possible values and conditions. But it has already been shown that the stress or tendency to rupture is equal to the moment of the weight $N = W x = W n l$ (n being a constant dependent upon the position and distribution of the load), and the resistance is a compound of the breadth, the square of the depth, and the experimental constant m, $R = m\ b\ d^2$. Hence

$$W n l = m\ b\ d^2.$$

Excellent tables, from which the values of m may be deduced will be found in the "Engineers' and Mechanics' Pocket Book," by Charles H. Haswell, Esq.

(To be continued.)

IMPROVED WORKING OF STONE QUARRIES.

By M. Camille Trougnoy. Translated from "Annales du Génie Civil" for "The Engineer."

We saw some months ago a granite quarry worked, at Beauvais-les-Rochers (for paving stone) with a powerful machine, invented by M. Joanne Ronceroy, which completely supplants powder and yet allows of the granite being detached in blocks and broken up almost without waste. The principal part of this machine is a monkey (drop) of 800 kilogrammes, carried with two iron rods which guide it in its fall, on a carriage which turns on the arm of a crane. This arm is horizontal, its jib is 12.50 metres in length, and about eight meters above the ground level. It is the fall of the monkey which detaches the blocks. A chain worked by a windlass raises the monkey when it has fallen, and nippers detach it when raised. The monkey is a mass of cast iron with two ears placed laterally on it, through which pass the guiding rods, and two more on the upper part by means of which the rope is fastened which, with the assistance of a pulley, serves to hang it on the raising chain carrying the nippers. The monkey is pierced by a hole opening into a cavity which receives a mass of iron (a die) on the lower surface of the monkey and which gives the blows. The object of the hole is to enable the die to be removed when worn. The guiding rods are round bars of iron twelve to fourteen meters long and six to eight centimeters diameter. They are kept at the same distance apart by a plate on the turning carriage, which has two holes bored in it of greater diameter than the rods. The lower part of the rods is fastened and kept at a fixed distance apart by a short iron strap, carrying two wooden blocks which can oscillate in the strap. Between the two blocks is left a free space through which the monkey can pass. The blocks of wood serve to deaden the shock after the blow has been struck on the stone to be detached. Finally, at each end the strap is provided with two pulleys, on which run two chains to raise and lower the rods at will. These chains work on a second windlass, independent of the one which belongs to the monkey. The carriage is like that used for the cranes of stores, and is worked by a chain from a third windlass. The arm of the crane is formed by joining two beams in the shape of a double T made of sheet and and T-iron, between which rolls the carriage. The complete machine carries three arms identically the same and symmetrically placed. The vertical shaft is borne on a large truck moving on rails, the surface of which is a square of five meters. On this platform is placed a horse-gin, to which the vertical axis serves as an axis of rotation. The horse-gin is hidden by vertical sides forming an enclosure, in which moves the horse which works the horse-gin. By means of a lever the different windlasses can be placed in connection with the horse-gin. Besides, the dispositions are such as that it is possible to give a rotary motion to the vertical axis to which the arms are attached, without displacing the platform of the horse-gin above the point on which it is to act. All the windlasses are placed on a second platform forming a kind of turn-table, placed high enough for the horse to pass under it, and on it stands the man attending to the working

of the apparatus. Under the large platform of the carriage is placed a mechanism which is attached to the horse-gin, and which, by means of a chain, draws backwards or forwards the whole system, which moves on rails.

The machine is used as follows: The upper part of the ground is levelled; a line five meters wide is laid perpendicularly to the face of the rock to be cut and five or six meters back; the machine is placed on this line. A man stands on the upper platform, and turns the apparatus so that one of the arms of the crane shall be about over a cutting previously made in the soil to admit a wedge which will serve to detach the mass; the carriage is then advanced or drawn back sufficiently so that the strap of the two guiding rods being lowered, the wedge can pass between the two wooden blocks; these blocks are carefully wedged with waste stone, so that they lie firmly on the stone, which they can do from the slight oscillatory motion they can take. The monkey is then raised to the required height to detach with a single blow the block of granite corresponding to the position of the wedge. The nippers are loosened, and the monkey detaches a block of from five to ten cubic meters. The placing in position of the apparatus and detaching of the block takes five minutes. Enough men must be employed to prepare the places of the wedges, either in the blocks to be detached or in those already detached, which are to be broken up. Each hole for a wedge in the granite takes an hour to make. The inventor states that twelve workmen, each having a man to help him, would be required, also a man to guide the machine, and five men to move and load, in all 30 men. The machine itself can assist in loading the blocks, as it is a regular crane. For breaking up small blocks. a special machine, which reminds one of a pile-driver is used, only the monkey, which is comparatively light, has a projecting cutter on its lower surface, and which is perpendicular to another cutter on a fixed cast iron anvil. The top of this anvil is surrounded by a framework, into which is put granite dust to the level of the cutter on the anvil; on this dust the block to be broken is placed and kept in position by means of a stiff wooden bar. It appears that considerable saving results from these two machines. They possess the advantage of not being liable to get out of order like that which has been used in the environs of Fontainebleau, and which necessitates the use of a steam engine—a kind requiring men accustomed to the management of steam-engines. It must, however, be admitted that this machine is very cumbrous, and one would like to know whether, by adopting the principle of the use of very heavy masses, for cutting rocks, a means could not be discovered which would permit of its application in the earthworks in the limestone and granite strata which will be met with in great numbers on the railways authorized in 1868.

ENGINEERING ARCHITECTURE, says President Haughton, in his address before the Mechanical Engineers, is a subject which the Society would do well to keep continually before it, because it is a line in which we can see our way, and in which every one admits there is room for improvement; it is, indeed, humiliating to think of the vast sums that have been spent in England on grand engineering works, with an utter disregard of appearances, and where a modicum of æsthetic skill would have given us so much effect and beauty. It will be said that utility and not beauty should be the cry of the engineer; but this is, after all, only the twaddle of incompetency, for it is well known to those who have given attention to art, that it costs no more to arrange materials in effective and pleasing forms, than to pile them in the shapeless masses that attract the eye. We must at once dismiss the assertion that beauty is costly; it is not meretricious ornament that is advocated, such as may be seen in at least one of the latest engineering works.

What I ask you to aspire after in those engineering works upon which you are engaged, is form, in the æsthetic sense, in place of that deformity which is sown broadcast around us, in which the British engineer has hitherto glorified himself, and in which he would seem to wish to idealize and deify sheer strength, which in his simplicity he sees to be incompatible with beauty of outline. Let the engineer above all things refuse to entertain the thought that veneration for the beautiful is beneath him as a man, or derogatory to the dignity and character of his race; for during all times those races which made themselves famous for their prowess and their majesty, their power alike over matter and mind, were equally renowned for the beauty and for the magnificence of their public works—those monuments of glory by which, history apart, we can now alone judge of their aristocracy of race.

HEATING AND VENTILATION.

Compiled from the late report of Alban C. Stimers, Esq., on the Ventilation of the Hall of the U. S. House of Representatives.

The term ventilation when applied to a hall of this importance should signify the production and maintenance within doors of pure air, properly tempered with heat and moisture, regardless of the existing state of the weather. A consideration of the subject is therefore properly divisible into the following heads:

1. The quantity of air necessary and how it should be introduced.

2. Warming and moistening the air in cold weather.

3. Cooling and drying the air in hot weather.

The subject of regulating the degree of moisture in the air when it is neither warmed nor cooled, is naturally involved in the above.

THE AIR SUPPLY.—A cubic foot of air at a temperature of 65° with the dew-point at 52° will absorb $2\frac{1}{2}$ grains of vapor. Each person exhales 15 grains of vapor per minute, and also requires $\frac{1}{4}$ cubic foot for breathing, $=6\frac{1}{4}$ cubic feet of air vitiated by each person per minute.

In supplying air for the ventilation of such a hall, it is absolutely essential that the direction of the current should be vertical; otherwise that which has been vitiated by one person will be given to another. If this envelope of vitiated air be drawn upward, the nose and mouth will be always supplied with it, no matter how pure the air may be one foot away; while, if it is drawn downward, those organs will always be supplied with pure air. The temperature of the human body rarely varies 2° either way from 98°. If, therefore, the air is supplied at a temperature of 65°, it will be 32° cooler than the body; with the downward current the head will be in this cool air, while the feet will be enclosed in an atmosphere nearly if not quite as warm as the blood within them. And to "keep the head cool and the feet warm" is one of the fundamental rules of hygiene as well as of comfort. A current of air coming up through the floor will always carry the fine dust which the greatest care cannot prevent accumulating. With downward ventilation it is only necessary that the dust shall be thoroughly removed from the inflowing air at the mouth of the inlet to keep the hall free from dust. Again: with upward ventilation, the entire hall is filled with vitiated air, the vitiation having taken place near the point of admission; while with downward ventilation the vitiation takes place near the point of exit, and the whole upper part is full of pure air.

During the downward movement of the body of air in a high room, all eddying currents, induced by the increased velocity through the apertures, become quiet, and the whole mass descends with a uniformity impossible to obtain in the vicinity of the persons ventilated with upward currents; and one of the most important considerations to be kept in view in ventilating an apartment is to avoid perceptible draughts. The only limit to the amount of air that can be advantageously supplied, is the avoidance of sensible currents. Most people can feel a current having a velocity of 150 ft. per minute; very few can perceive one of 90 ft. The maximum velocity proposed in this case is 50 ft., and the hall being $139\frac{1}{3} \times 93$ ft. in plan, the quantity of air required would be 647,900 cubic feet per minute.

The first method adopted by engineers and architects to give movement to air, for the ventilation of mines and buildings, was to heat an upflowing column, thus lessening its specific gravity and causing it to rise with corresponding force. That system is still employed in the British houses of Parliament. It has been practically demonstrated, however, that one pound of coal burned in the furnace of a steam boiler, which furnishes steam to drive a fan blower, will generate as much force, and consequently is capable of producing as strong a current of air, as 38 pounds expended in heating a column of air to act by its diminished gravity. English engineers commenced about ten years ago to apply fan blowers to the ventilation of mines. The French had previously adopted this practice. In addition to the economy of this method, the complete control which the attendant is enabled to maintain over the quantity of air supplied at all times, is found to be of great advantage.

To propel the air into this hall it is proposed to place four fan blowers, having a capacity of 200,000 cubic feet per minute each, in the cellar; thence the air passes up through shafts to the chamber above the ceiling. Here would be placed an additional ceiling of plate glass and iron, of double thickness, that it might be a non-conductor of heat, and above this the gas burners. The air would thus be thoroughly distributed over the ceil-

ing before passing into the hall. Such openings through the present ceiling would be provided, that its present ornamental appearance would not be changed, and an equal area of opening would be obtained in each of the 165 squares into which it is divided. To insure the continuance of the air thus admitted, in a direct vertical line down to the floor there would be frequent openings throughout their extent, which should communicate to the air-chamber beneath the floor. The air from this chamber would be withdrawn by means of four fan-blowers of equal dimensions with those employed to drive the air in. From the blowers the air passes up through a separate duct, by the side of the pure air duct already mentioned, and goes off through the roof.—All these blowers would be driven by one pair of engines of 750 h. p., through the medium of appropriate gearing, shafts and belts. In every case of gearing there would be wooden teeth working into a cut metal gear, which, may be made to run with perfect silence, and is more durable than metal gearing. By running all the blowers from one engine, a uniform relation of the forces employed in different localities is secured.

Merely forcing fresh air in, would drive the foul air out, but this would mostly occur through the nearest and easiest passages, so that the fresh air would not be properly distributed. Simply drawing air out would cause in-currents from all doors and windows as well as from the intended supply duct. Excess of either induction or withdrawing forces would tend to produce these respective results. The only perfect distribution of the air will result from having the filling and exhausting forces the same.

The present place of admitting the air, near the ground, is very objectionable. Even admission by high towers would not secure air free from dust. The plan here proposed is to sink a shaft 25 ft. in diameter, some 200 ft. west of the building, in a small grove. Over it would be erected a substantial screen, 22 feet in height, and similar in form to the Capitol dome. It would be made of $\frac{1}{4}$ wire of pure block tin, that it might be durable and always clean. The meshes would be about $1\frac{1}{4}$ inch. Over the top of this there would be a revolving fountain with four jets, which would project downward, throw small streams of water with force upon the wire work of the screen, and keep every wire covered with an envelope of clean water, against which the entering air would have to rub in passing in. This forcible contract would transfer the dust from the air to the water. The muddy water would fall to the bottom of the duct and pass away by the drain through a trap. From the bottom of this vertical opening a tunnel 15 ft. in diameter would extend horizontally to the blowers in the cellar so enclosed as to draw their air wholly from this source. The tunnel is 15 feet in diameter, and the top of it passes 16 feet below the lowest point of the foundations of the building.

Warming the Air in Cold Weather.—There are three methods in common use for warming air; by passing it over, 1st, iron surfaces heated directly by fire; 2d, iron pipes filled with steam; and 3d, iron pipes filled with hot water. The first method is considered highly objectionable in first class buildings. When air is brought in contact with highly heated iron surfaces, especially rusty surfaces, an unpleasant odor and feeling are imparted to it, from the decomposition of those ammoniacal matters which are always found more or less in the atmosphere, and from its extreme dryness. Zinc surfaces are a great improvement over iron, in this respect, but block tin is considered the best material, as it resists atmospheric influences better than any other of the useful metals.

The means here recommended are pure block tin tubes filled with hot water, each tube being 10 feet long by $1\frac{1}{8}$ inches outside diameter and secured into brass tube-heads in the same manner as in the surface condenser of a marine engine. They open at each end into steam-tight chambers; into the upper chamber steam from the boilers is introduced, and from the lower one water is drawn off by appropriate pipes. It will be understood that with this arrangement the apparatus may be a steam heater, or, if the surface is enlarged enough to warm the air with hot water, the steam will be condensed in the upper chambers, hot water filling the bottom of the tubes and the lower chambers. A valve in the pipe through which the water flows away would control the rapidity with which it was drawn off and consequently its temperature. In ordinarily cold weather this would be a hot water warming apparatus, but upon any extremely cold day it would become a steam heating apparatus as the attendant opened the regulating valve in the drain pipe.

Moistening the Air.—The water thrown off by the human body, evaporates in the surrounding air. The rapidity of this

evaporation is dependent entirely upon how far the condition of the air in regard to moisture is removed from the point of saturation. In case the evaporation from our bodies is too rapid, the skin becomes too dry, and this again induces too rapid a flow of the water within the system toward the surface, making us uncomfortable, and sometimes ill. Evaporation is also a cooling process. This is explained by the absorption of the latent heat which occurs upon the conversion of a liquid into a vapor. On the other hand, if the evaporation is too sluggish, the flow of water toward the surface is retarded and we are made uncomfortable and sometimes ill in another way; also, if the air is of the proper temperature, we are uncomfortably warm, the general feeling being described by the term "muggy." It is highly important, therefore, that the proper moisture of the air should be maintained in any system of ventilation.

An authority on this subject* says: "Air changed in temperature by warming, *without increased moisture*, produces unpleasant sensations in the head and chest, etc. The objection lies against heated air, no matter how heated. The only way that hot air can be made healthful is by an effectual plan of artificial evaporation." Professor Henry says on this subject: "The heating af the air and preserving it at the desired temperature is the simplest part of the problem; to remove the impure air and to supply its place with fresh air, without giving rise to unpleasant currents and unequal temperature is more difficult; to supply the proper quantity of moisture and to prevent its condensation is attended with still greater difficulty, particularly when apartments containing a large number of persons are to be thoroughly ventilated. This part of the general problem is, in my opinion, an essential element of proper ventilation, although it has hitherto received comparatively but little attention in this country."

Mr. Stimers' plan for moistening the air is by placing in the air duct, a system of water pipes, 10 in number, each 20 feet long, lying horizontally, lengthwise of the duct, and distributed throughout its cross section so as to equally divide it up. In each of these pipes there would be a great number of minute holes extending all around the circumference and throughout the length. The water driven into these pipes with force would spin out of these holes radially from each pipe, filling the entire duct with a fine shower.

The "relative humidity" of the air is the percentum which the amount of moisture in the air is, of that necessary to saturate it at the same temperature. A relative humidity of 65, with a temperature of 65°, is assumed; this corresponds with

$4\frac{1}{2}$ grains of water per cubic foot of air.
A tension of 0.4 in. of mercury.
A depth of $5\frac{1}{4}$ in. of water on the earth.
A break between the wet and dry bulb thermometers of $5\frac{1}{2}°$, and
A dew point of 52°.

The lowest degree of humidity of the external air of Washington, as reported by Dr. Wetherell, was 1.11 grains per cubic foot. Assuming one grain for the base of calculation, there will have to be added $3\frac{1}{2}$ grains per cubic foot to give it a relative humidity of 65 when at a temperature of 65°, and as there are 7,000 troy grains in one pound avoirdupois, 80,000 cubic feet of air will require $\frac{80{,}000 \times 3\frac{1}{2}}{7{,}000} = 40$ pounds of water per minute.

The temperature of the water would probably be about 40°. This would have to be warmed to 65°, and be supplied with the latent heat necessary to form it into vapor at that temperature.

To ascertain how much the air must be superheated for this purpose—

Let s = specific heat of air as compared with water ..... = 0.2669
v = volume of air in cubic feet.... = 80,000
w = weight of air in lbs. per c. ft.. = 0.075
t = temperature from which water is raised..... = 40°
t' = temperature to which water is raised ..... = 65°
l = latent heat of steam at that temperature..... = 1070°
W = weight of water to be absorbed in pounds..... = 40
x = number of degrees the air must be heated above 65°, in order that it may be at that temperature after it has dissolved the moisture.

$$\text{Then } \frac{W\,(l + t' - t)}{svw} = x = 27°.$$

The temperature to which the air must be raised, under the above conditions of the weather, before it is moistened, would therefore, be—

$$65° + 27° = 92°.$$

To determine the extent of surface required for the warming tubes—

Let P = temperature of water in tubes = 192°
T = temperature of air after heating..... = 92°

*Dr. Youmans Hand-book of Social Science.

Let t = temperature of external air.. = 20°
C = volume of air in cubic feet... = 80,000
S = surface of tubes in square feet.

$$\text{Then } .0045\ C\ \frac{(P-t)\ (T-t)}{P-T} = S$$

and S = 44,582 square feet.

Each tube being 10 feet long by $1\frac{1}{8}$ inch diameter, would have a surface of 2.9 square feet. There would, therefore, be required 15,373 tubes. These are divided into eight several congeries, for convenience of construction, with 1,922 tubes in each. It is proposed to arrange indicators in the engine room, so that the engineer would always know the exact temperature and moisture in the hall, and could regulate the heat and water accordingly.

Cooling and Drying the Air in Hot Weather.—An attempt has been made to cool the air of this hall with ice. Some two tons of ice were melted in the air-duct during each day of about five hours, say 800 pounds per hour. The quantity of air passing through the duct, per minute, was 24,300 cubic feet.

The temperature of the ice was, say ..... 25°
That of the water of condensation was, say, 60°
The latent heat of the ice is ..... 140°

To determine how much the air would be cooled by melting the ice—

Let t = temperature of the ice..... = 25°
t' = temperature of the water of condensation ..... = 60°
l = latent heat of ice..... = 140°
s = specific heat of air ..... = .2669
w = weight of air per cubic foot.. = .075
v = volume of air in cubic feet... = 24,300
W = weight of ice melted per min., = $13\frac{1}{4}$
x = number of degrees the air would be cooled by the melting of the ice.

$$\text{Then } \frac{W\ (l + t - t)}{swv} = x = 4\tfrac{3}{4}°.$$

As, however, the air thrown in by the blower was mixed up with that which flowed into the hall through the open doors, the temperature of the hall was only reduced about one degree by the melting ice.

Taking the maximum temperature at 95°, and the maximum moisture in the air at nine grains per cubic foot; to reduce the temperature to 75°, and the relative humidity to 65, we must abstract three grains of water from each cubic foot, or $\frac{80{,}000 \times 3}{7{,}000}$ = 34.3 pounds from the whole quantity per minute. At the moment of the condensation of this water, from a vapor into a liquid, its latent heat is given out into the air; so that removing the vapor is a warming process. The additional extent which the air must be cooled to compensate for this is expressed by the formula—

$$x = \frac{W\ l}{s\ v\ w}$$

Where W = the weight of water in lbs. = 34.3
l = latent heat of the vapor.. = 1091°
s = specific heat of air..... = .2669
v = volume of air in cubic ft., = 80,000
w = weight of air per cubic ft., = .075
x = the number of degrees the air will be warmed by the condensation of the vapor.

With the above values, x = 24°.

The entire cooling effect must, therefore, be equivalent to 44°. This would require 24,000 pounds of ice to be melted per hour, or, say, 60 tons per daily session of five hours.

Coal is cheaper than ice per ton, and more conveniently stored and handled. One-sixth of the above quantity burned in the furnace of a steam-boiler will produce, through the medium of appropriate mechanism, an equal cooling effect upon the air. Machines are operated by the steam engine for the manufacture of ice, which produce cold by pumping off the vapor of sulphuric ether, or of the bisulphide of carbon; these liquids vaporizing rapidly at low temperatures if the pressure of the superincumbent atmosphere be removed; but the employment of such substances would be inadmissible in cooling the air for ventilation, as a slight leak in even one of the many necessary tubes would impair the purity of the air to a sensible and objectionable extent.

Mr. Stimers, therefore, proposes to employ the steam power to drive air-pumps to compress a portion of the air, making it hot, and while under this pressure to cool it down to the ordinary temperature by passing it through tubes surrounded by flowing water, (employing an apparatus precisely like the surface condenser of a steam engine,) and then let it expand into the duct. This expansion would be a cooling process exactly corresponding in extent to the heating one the air underwent when it was compressed, and by mixing this excessively cold air with the warm air from the blowers, the whole would be brought to the desired temperature.

It is mechanically convenient, in a machine of this kind, to compress two volumes of air into one, in the pumps. To learn how much such an amount of compression would elevate the temperature, a formula is given by Peclét*, as follows :

* *Traité de La Chaleur; tome III, p.* 10.

Let θ = temperature before compression (Centigrade).
d = density before compression.
θ' = temperature after compression.
d' = density after compression.

Then $\theta' = (274 + \theta)\left(\frac{d'}{d}\right)^{0.42} - 274.$

In this case

$\theta = 35°$ (= 95° Fahr.)
$d = 1$
$d' = 2$

and consequently

$\theta' = 139.44°$ Cent. or 283° Fahr.

and the elevation of the temperature would be 188° Fahr.

To find how cold the air will be after its expansion, we have

$$\theta = \frac{\theta' + 274}{\left(\frac{d'}{d}\right)^{0.42}} - 274.$$

Assuming 20 lbs. pressure in the air condenser, and 75° Fahr. (23.89° C.) temperature of the water: as the heat was abstracted from the air it would be further condensed $\frac{1}{480}$ part with the departure of each additional degree, the pressure being maintained; hence we would have

$\theta' = 23.89$
$d = 1.$
$d' = \frac{14.7 + 20}{14.7} = 2.36,$

whence $\theta = -66.12°$ Cent. or $-87°$ Fahr.

This would be a reduction from its original temperature of 182°. This being slightly more than four times the amount of cooling force it is necessary to apply to the whole quantity of air furnished, one-fourth of that amount, or 20,000 cubic feet, will require to be passed through the pumps. The dimensions of the air-pumps and engines will be as follows:

Number of pumps	2
Diameter of pistons	65 inches.
Stroke of pistons	6 feet.
Double strokes per minute	40
Diameter of steam cylinders	45 inches.
Steam pressure	40 lbs.
Gross effective steam pressure	29 lbs.
Horse-power	1,200.

If the cold air was simply conveyed to the air-duct and mixed with the warm air from the blowers, it would be cooled down below the desired temperature, and a portion of the moisture it is desirable to abstract would be condensed in the form of a fog and carried along with the air into the hall, which would thus be filled with a cold, damp air, highly objectionable. It is necessary, therefore, to have the cold air introduced in a peculiar manner, such that not only may the moisture be abstracted, but that the exact amount removed may be subject of convenient and easy regulation by the engineer in the engine-room. The character of this regulation must necessarily be that the power exerted by the engine shall determine the extent of the cooling force, and that the amount of this which shall be devoted to reducing the temperature of the air, and that which is devoted to abstracting the moisture, shall be subject to a regulating lever, or hand-wheel; so that if the engineer moves this in one direction, the air will be made cooler and more moist, and if in the other, it is made warmer and dryer, the cooling engine continuing to run at the same rate.

To accomplish this it is proposed to erect, in each of the two cooling and drying chambers of the air ducts, a congeries of tubes somewhat similar to those employed for warming the air in cold weather, only there would be an additional chamber, or chest, at mid-height; in fact, two systems of tubes, one above the other; in other words, it would be two stories high. In the two upper chambers there would be openings in the bottom in all the spaces between the rows of tubes; these openings controlled by valves, and the valves appropriately connected with hand-levers in the engine room; there being one for a system of valves which would control the openings in every third space between the rows, and one for those in the remaining spaces. The aggregate area of the openings in the lesser system should equal the area of the pipe which brings the compressed air from the cooling engine; those in the other spaces, being of the same dimensions, would have in the aggregate twice this area. Then the compressed air should be conveyed by a pipe from the cooling engine to the lowest chamber, thence it would flow upward through the tubes into the upper chambers, then downward through the openings into the spaces between the tubes. The operation of this arrangement would be as follows:

Let us imagine a condition of the external air such as has been assumed for a maximum performance of the cooling engine. In this case let the openings in two-thirds the spaces between the tubes be closed, and those in the remaining spaces be wide open; the area of the whole being such that it

would require a pressure of 20 pounds per square inch to drive all the air supplied by the pumps through them. It will be perceived that the pressure throughout, from the pumps to the exit, will be 20 pounds per square inch, and that, therefore, the temperature will be maintained at 75° while the air passes through the tubes. As the compressed air pours down between the two rows of tubes, and expands to the ordinary atmospheric pressure, its temperature will fall so suddenly that the moisture within it will be condensed, and part of it frozen into minute hail. The main portion of the air from the blowers will pass through the remaining spaces between the tubes, and as they are only one-eighth of an inch apart in the rows, they form, in effect, walls of separation between the warm and the cold air A sufficient quantity of the air from the blowers will, however, pass into the cooled spaces to carry forward the hail storm raging there, and as the hail and condensed moisture are carried along the narrow spaces they will come in contact with the surfaces of the tubes and be deposited upon them. The temperature of these will be too low to vaporize the moisture, but warm enough to melt the hail, and the water will run down them, as it does along the sides of an ice-water pitcher, to the bottom tube-sheet, whence it will pass off in proper drains prepared for it.

If the warm air issued from the dryer with the same velocity as the cold, exactly one-third of the whole amount would be excessively cooled, and nearly all its moisture extracted; but the great velocity with which the compressed air will pour into the spaces between the tubes, having only to be changed in its direction by the horizontal current from the blowers, will flow out with considerably greater velocity than the warm air from the remaining spaces; so that something more than one-third of the moisture contained in the whole amount of air will be deposited upon the tubes and carried away. In the case under consideration, exactly one-third is the amount it is desired to extract. The necessary reduction will be made by slightly opening the valves in the remaining spaces; the immediate effect of which will be to cool down all the tubes by causing a partial expansion of the air within them; so that the warm air will be cooled somewhat by coming in contact with the tubes, in addition to having some of the cold air mixed with it. This will lessen the extent to which the temperature will be reduced in the cold spaces, and, consequently, the amount of moisture will be condensed and extracted.

To enable the engineer in charge to control the condition of the air delivered to the hall, it is proposed to place pipes about three inches in diameter, and properly incased with a non-conductor, from the inlet duct, from the tempering ducts just beyond the moisteners, and from the hall; leading them through a convenient place in the engine room, for observation, to the suction openings in the blowers, which would cause a rapid flow of air through them, having the exact condition existing at the other ends of the pipes. Into each of these pipes, as they pass through the engine room, the wet and dry bulbs of a hygroscope would be inserted, which should plainly indicate the temperature and degree of moisture in the air passing through the pipes.

The method here recommended for drying the air when it is too moist, or when it is made so by reducing its temperature, is simply the adoption upon a small but sufficient scale of that employed by nature in effecting similar changes of weather.

Cost.—The actual cost of the complete apparatus described, is estimated by Mr. Stimers at $688,653. The following are some of the items:

Eight blowers and shafting for 200,000 c. ft. per min. each	$11,194
Pair of engines 750 H. P., with wood gear fly-wheel, erected complete	46,102
Four boilers, with 13,744 sq. ft. surface, and of 1,370 H. P.	63,416
Heating apparatus, with 44,582 sq. ft. block tin tube surface, with steam and water pipes and valves	123,018
Pair of condensing engines of 1,320 H. P., with 45 in. steam cylinders, and 65 in. air cylinders, 6 ft. stroke and a cooler with 9,000 sq. ft. brass tube surface, erected complete	94,552
Drying apparatus, with 5,570 sq. ft. block tin tube surface, with valves, complete,	30,754

Steam Farming Power.—It is but a very few years since a portable engine for farm use was a curiosity, nor is it so very long since such a thing was unheard of. Now, we find a single establishment capable of turning out a thousand yearly, of a design and finish equal to the best locomotive practice. There are at least four makers in Lincoln alone, one of them having magnificent works. More than 15,000 portable engines are known to have been sent out during the last eighteen years.—*Engineering.*

FASTENING CAST STEEL DRIVING TYRES. — The following rules, for shrinking on cast steel tyres, were issued by W. A. Robinson, Mechanical Superintendent of the Great Western (Canada) Railway:

1st. Both tyre and wheel must be perfectly cylindrical.

2d. These tyres are to have allowed, in their cold state, the amount of shrinkage shown in the following table, according to their respective diameters:

Letter of tyre.	Internal diameter of tyres.	ALLOWANCE FOR SHRINKAGE.		
		Decimal parts of an inch.	Fractional parts of an inch.	Wire gauge.
A	Ft. In.			
B	2 2¼	.014583	1-69	28
C	2 8	.017	1-56	27
D	2 9	.0183	1-54	26
E	3 2	.021	1-49	25
F	3 4¼	.0225	1-44	24
G	3 8	.024	1-41	23
H	4 3¼	.028472	1-35	22
J	4 7	.0305	1-33	21
K	4 8	.031	1-32	21
L	5 2¼	.034583	1-29	20
M	5 3	.035	2-57	20
N	5 7⅞	.0377083	2-53	20
O	5 9	.0383	1-26	19

3d. Wood only is to be used to heat the tyres, and temperature must not be allowed to exceed a dark red glow in the shade, and all parts must be heated equally to insure uniform hardness and roundness. To facilitate the operation, each foreman is provided with a set of steel gauges corresponding to the above figures.—*American Railway Times.*

STEEL RAILS, TYRES AND FIRE BOXES. —The last report of Mr. Sayre, Superintendent and Engineer of the Lehigh Valley Railroad, treats these subjects as follows: "I have seen no reason to change my opinion of the value of steel rails as compared with iron; another year's wear has made no perceptible impression upon the 200 tons, the first of which was laid in May, 1864, none of which have broken or given out since last report. These rails have had a severe test, being in those places in the track where they are subject to the greatest wear, and being laid with a chair which is much inferior to the most approved joint now in use. * * * There is no longer any possible doubt as to the superiority of steel over iron in economy, as in every other respect." The report goes on to say that a large additional quantity of steel rails and a few steel headed rails have been contracted for.

As to steel tyres, the report say: "The experience of the past year has confirmed our favorable opinion of steel tyres. There were on the road at date of last report 57 locomotives furnished with steel tyres." This number has now been increased by 19 engines. "Although in one or two instances they have not done as well as we could wish, yet none of those of reliable manufacturers have failed, and the result in general has been very satisfactory. "The steel tyres of engine No. 25 put on December, 1863, have made 106,185 miles and are good still.

There were steel fire boxes on 14 engines at the date of former report. "All have given good satisfaction during the year except those of engines 50 and 51, which were not of good quality and have given us continual trouble. We now have in use 29 fire boxes of steel. The first one, put in January, 1862, is still good. All the engines contracted for, or which we build ourselves, are furnished with steel fire boxes and tyres."

THE DARIEN SHIP CANAL.—By Mr. Cushing's mission, all political obstacles to the construction of this great work are removed; it is understood that American engineers have secured from the Government of New Granada, both the right of survey and the right of way across the Isthmus. A company including Peter Cooper, Marshall O. Roberts, Wm. H. Vanderbilt and other equally well known capitalists, was chartered by the New York Legislature last winter, and have since become fully organized as a joint stock company to undertake the work.

Many routes have been surveyed, but that from the Gulf of San Miguel to Caledonia Bay, and the one from Bayone River to the Gulf of San Blas have appeared most feasible. The latter route has deep and spacious harbors and would require but 30 miles of canal. The tunnel through the Cordilleras would be seven miles long, 100 ft. wide and 115 ft. high to allow steamers to pass, and even a first-class man-of-war, with her topmast and top-gallantmast struck and her yards braced.

THE HOOSAC TUNNEL.

The contract for this work, between the Messrs. Shanly and the State, made Dec. 24, 1868, is published in full in the "American Railway Times" of Jan. 30, 1869. The tunnel, central shaft and one track are to be completed by March 1, 1874; the price to be paid is $4,594,268. A delay in the rate of progress through the most difficult part is provided for, but the final delay must not exceed six months, and if the State decides that the contractors are not making the necessary average progress, it may give them three months' notice to quit the work. No payment is to be made to the contractors until they have earned $500,000; but 20 per cent. of the monthly amounts of pay earned is to be reserved for final payment on completion of the whole work; and, for 80 per cent. of each monthly amount, certificates in the sum of $200,000 each, bearing five per cent interest are to be issued, and to be paid in the order of their issue as often as it shall appear that the contractors have earned so much that after reserving the 20 per cent., the State will still retain in all, $500,000. The intention is that the State shall make no payment which will at any time reduce its security from the reserved fund of 20 per cent. below the said half million dollars.

The size of the tunnel, in rock, is 24 feet clear width and 20 feet height; where arching is required, 26 feet wide and 21½ feet high. The central drain is 2 feet square. At the east end, the work done is 2,500 feet of tunnel, part of which is full size, and 2,782 feet of heading; the work to be done is tunnel enlargement 4,500 yards, heading enlargement 28,000 yards, tunnel extension 5,300 feet long=85,100 yards, trench and pipes 5,600 feet long, and the railroad track. At the central section the work done is sinking 583 feet of elliptical shaft 27 by 15 feet; the work to be done is to make a fire-proof floor with self-closing iron hatches, to sink the shaft to a depth of 1,030 feet (floor of tunnel) to set up two ten-inch iron pipes for power and ventilation, and to excavate the tunnel east and west to meet the end workings, with drain and track. The work done at the west end is a shaft 318 feet deep, 8 by 14 feet, and headings from it 1,609 feet east and westward to the west end, a pumping shaft 277 feet deep, and an auxiliary shaft 215 feet deep. The work to be done is enlarging the headings (52,800 yards), extending the tunnel east to meet central working, arching part of the tunnel with brick (4½ million bricks to be used), and the end with stone, having a suitable facade, and laying drain and track as above. The State gives the contractors the use of all plant, tools, &c., on hand.

As a more rapid progress of the work is required than drilling by hand labor would accomplish, upon each of the advance headings, between the east portal and west shaft, the contractors will be required to use pneumatic drills, working continuously not less then eight drills to a heading of eight feet height, with not less than 50 lb. air pressure, but with the liberty to employ the form of machine now in use in the tunnel, or any other drill of equal efficiency which they may prefer and provide at their own expense.

The prices for the work, fixed to determine the monthly amounts earned, are as follows:

Tunnel enlargement, per yard	$16 00
Heading enlargement east end, per yard	9 00
Heading enlargement west end, per yard	9 75
Full size tunnel extension east end, pr yard	11 00
Full size tunnel extension central section, per yard	14 60
Full size tunnel extension west end, pr yard	12 00
Central drain with air and water pipes complete, per lineal foot	13 00
Sinking shaft (27×15 ft.), per foot in depth	395 00
Pipes (10 in.) set in shaft depth	6 00
Arching with brick (at $9 per M.) per M	22 00
Excavating and constructing 50 linear ft. of stone arch and filling	23,000 00

The extreme length of the tunnel will be about 4¾ miles, of which some three miles are yet to be excavated.

THE PITCH LAKE OF TRINIDAD ever and anon claims the attention of the public. At one time it is introduced as the source from which all the varieties of mineral oil, paraffine and asphaltum can be obtained. At another period it is to be employed to give greater illuminating power to our coal-gas, and some experiments of the Hon. Captain Cochrane, made at Woolwich, were highly favorable. Now we have the pitch of Trindad coming before us as an ingredient in artificial fuel for steamers. The bitumen is mixed with a certain quantity of charcoal: it is ground, and then made into bricks. Experiments made on board H.M.S. "Gannet," appeared to show that it possessed many valuable properties, but the amount of ash, arising from the earthy matter mixed with the petroleum, was somewhat objectionable. This can, however, in all probability, be obviated by greater attention in the process of manufacture.—*Quarterly Journal of Science.*

MINING.

PRESERVATION OF HEALTH AND LIFE—MINING MACHINERY.

From the "Quarterly Journal of Science."

The shortness of the average duration of a miner's life has often been the subject of the most serious consideration. The Royal Commission, of which Lord Kinnaird was the chairman, made this portion of their inquiry a most searching one. It is clear, from the evidence given by medical men and others, that the metalliferous miner suffers in health from climbing on the perpendicular ladders from great depths, from working in air deficient in oxygen, and from the severe labor of boring holes for blasting in confined levels. The constrained position of the man in "beating the borer," and the muscular effort necessary to deliver the heavy blow, act injuriously upon the heart and lungs.

The miner has been relieved to some extent from the effects of climbing, by the introduction of the "man-engine" (a movable rod with platforms fixed upon it, by which the miner is gradually lifted—without fatigue to himself—from any depth to the surface). The ventilation of the mines generally has been improved, but it is only within the present year that any actual experiment has been made in the mines on the use of machines for boring holes, worked by compressed air or steam. We have been favored, upon application, with the following report. We are glad to place this on record, as the commencement of an application of machinery to a most important purpose. We have no doubt that in a short time boring-machines will be generally adopted in our metal mines.

"Dœring's rock-boring engine has been worked on the 185 fathom level in Tincroft Mine, conjointly with another, from the 6th of January up to the present time, and has driven sixteen fathoms in hard Tin Capel, which Captain Teague considers would cost 20*l.* per fathom if driven by hand-labor. During the greater part of this time, in consequence of the air-pumps getting constantly out of repair, the machine was only worked by one (shift) corps of two men; and continuous working with three corps, comprising five men and one boy, only commenced on the 6th of July. Since this date nearly nine fathoms of ground have been driven, at a cost of 17*l.* 16*s.* 2*d.* per fathom. The following is the cost of working the machine during the last month:

	£.	s.	d.
Five miners and one boy	24	0	0
One boy to remove rubbish	2	0	0
Two enginemen at surface	6	0	0
One smith and boy	5	5	0
Oil, waste, and candles	3	9	0
Gun-cotton for blasting	4	10	0
Fuse	0	7	6
Sundries	0	3	0
Coals	6	0	0
Repairs	2	0	0
	£53	14	6

"In the above estimate the sum of 21*l.* 5*s.* is for expenses at the surface, which would be but slightly increased if three ends were driven instead of one—say about 2*l.* 15*s.* This would reduce the average cost per fathom 13*l.* 9*s.* 10*d.*, instead of 17*l.* 18*s.* 2*d.* During these last three months one corps has been worked by one man and a boy, and the result has shown that they will drive as much ground with the machine as two men could do in the same time. (Signed) F. B. Dœring."

We find, during a recent visit to the Cornish mines, that the patentee is offering to contract for sinking shafts and driving levels upon such terms as will, without doubt, induce many mine adventurers at once to close engagements with him.

General Haupt's machine for boring is about to be introduced into the lead mines of Swaledale, in Yorkshire; and Mr. Lowe's machine is in use in several large railway cuttings and tunnels.

Our miners must (in consequence of improved mining abroad) direct their attention towards the application of machinery, so as to economize in every direction—not merely in the subterranean mining, but in all the surface operations. Necessity—the mother of invention—has already done much in this way; but there is yet ample room for very considerable improvement in the modes of working our mines, and in the methods of dressing the ores for the market.

In connection with this subject we may name—as we do with satisfaction—the increased desire on the part of the Cornish miners to avail themselves of the many advantages offered to them by the Science Classes of the "Miners' Association of Cornwall and Devonshire." We learn that four classes are now in operation in the mining districts around Helston, in which sixty working miners are proving themselves apt students of Chemistry, Mineralogy, Geology and Mechanics. One class of nearly thirty is no less actively engaged at Redruth, another in the mining parish of Gwennap, while a seventh have been recently been formed in the northern portion of the important mineral district of St. Just. The advantages which must result from these classes will, ere long, be felt in the improve-

ment of mining and in the elevation of the miners.

The explosions of fire-damp in some of the coal mines of France has naturally drawn attention to the subject of ventilation. M. Galy-Cazalat, who has brought the matter before the Académie des Sciences, proposes the construction of vertical air-pits, the purpose of which would be to draw off the carburetted hydrogen as rapidly as it is formed, and thus prevent its mixing with the air of the mine. These "*cheminées d'aspiration*," as he calls them, will scarcely require very special description, the whole plan really resolving itself into a greatly increased number of shafts, by which the air in every part of the mine may be rapidly changed. There can be little doubt that great advantages would arise from such a system: but in the large and deep collieries of this country there are many serious difficulties standing in the way of its introduction.

M. Delaurier has brought before the Academy of Sciences a plan for *destroying* fire-damp in coal-mines. He proposes to place copper conductors of considerable thickness in the galleries; these are to be broken at intervals, and united by means of very thin gold wire, which is to be covered with sulphur. By passing a strong current of electricity through those conductors, the sulphur is ignited, and if any fire-damp be present it will be fired. This idea is by no means new. The Academy is said to have spoken approvingly of the proposed plan; but all coincided in the opinion that regular and powerful means of ventilation could in no case be dispensed with. The combustion of the *fire-damp* would produce *choke-damp*, which it would be necessary to remove. This plan, like many others which are from time to time brought forward, evidently originated with one who was but imperfectly acquainted with the conditions under which fire-damp is formed in a colliery.

CALCULATING AREAS.—Mr. J. L. Haddon, Chief Engineer to The Syrian Government, communicates to "the Engineer," his method of simplifying the tiresome calculations necessary for taking out areas, more especially when of curved or irregular surfaces.

Principle.—Take paper of good manufacture (tracing or otherwise), and it will be found that its substance is very accurately distributed; any one square inch weighing precisely the same as any other—even in common papers it varies but slightly. The thicker the paper for my purpose the better.

Example.—Required to find the area of any map.

The paper on which the map is drawn is first to be accurately squared, the area thereof computed in inches, and its weight accurately ascertained. Next proceed to cut out carefully all that portion, the area of which is required, and weigh that also. Then as the weight of the whole is to weight of the portion cut out, so are their respective areas.

Suppose the scale of map to 20 miles = 1in., size of map, 20in. × 10in. = 200 square inches; weight of map, say, 2,000 grains. Then if weight of piece cut out is 1,500 grains, the area of it will be 150 square inches or 3,000 square miles.

In cases where the plan or map is valuable and it is not advisable to destroy it, a tracing of the part required has to be made, and the same process gone through for finding its area.

For iron sections, earthwork calculations, agricultural surveys, etc., it will be found most useful.

THE SICILIAN SULPHUR MINES have been long known. More than 600 mines have been at work, and at least 200 worked out and abandoned. The mining is of the most primitive character, the use of machinery being extremely limited. Not less than 22,000 people are occupied in working those mines, and the result is the production of sulphur to the value of not less than 17,600,000 francs per annum. The sulphur ores of Spain are now largely imported into England, and during the past year, not less than 500 tons of copper have been separated from sulphur-ash, after the sulphur has been expelled by burning, although the pyrites does not contain more than from 1 to 2 per cent. of that metal.

AGRICULTURAL IMPLEMENT MUSEUM.—Under the title of a Permanent Exhibition of Inventions and Improvements, a new section has been added to the Museum of Agriculture in Russia, the object which is to supply those who have invented or improved agricultural machines, implements or methods, with ready means of communication with agriculturists and the public. The machines, models, plans or drawings are to be exhibited gratis for six months, at the expiration of which time they will be returned to the inventors or destroyed, unless they should have been purchased for the Museum.

THE PIG IRON MANUFACTURE.

The great primary want of the manufacturer of malleable iron and steel, is better qualities of pig iron, such as can be produced from blast furnaces of the most approved construction. As a rule it may be set down that all the inferior ore and fuels may be worked to produce comparatively good results, when proper attention is paid to the details of construction of the furnaces, and preparing the materials for use, combined with skillful attention to the details of the manufacture. Every one familiar with this branch of science, is aware that the impurities contained in the materials are to some extent absorbed in the metal in the smelting operation, and that in numerous instances the fuel is very impure and imparts its deleterious properties to the pig metal. Hence it must be obvious that any means that will promote economy in the use of fuel will obviate this difficulty to the extent of the saving of the fuel. The improvement of pig iron is to be obtained by increased size and height of the furnace and by the use of a highly heated, uniform temperature of blast. A combination of these improvements are necessary to obtain the best results, for it has been found that with the same temperature of blast, in furnaces of fifteen feet bosh, given materials will produce inferior qualities of metal, while by using larger furnaces they produce improved grades of iron at a greatly diminished cost of production. To illustrate this we give the working of blast furnaces in the Cleveland district in England, using lean ores containing large percentages of sulphur and phosphorus, and as a rule with very inferior fuel. About six years ago the size of furnaces in this district varied from 14 feet to 18 feet boshes and about 50 feet high; the iron was unfit for any purpose where good quality was desired. Since the high, large furnaces have been adopted, with blast heated to 1,000° to 1,200°, the quality has improved to such an extent that the pig is now used for almost every purpose except the manufacture of steel. The most noted and successful examples of the large improved furnaces, are those of the Norton Iron Co. at Norton, England, and the Ferry Hill furnaces; they are respectively 25 feet boshes and 85 feet high, and 27 feet boshes and 102 feet high. These furnaces make the ton of best foundry iron with 17 to 19 cwts. of coke. The Norton furnaces, owing to more skillful engineering in the design and construction, produce more iron per week than the Ferry Hill furnaces, although considerably smaller. A large portion of the excellent results of these furnaces is attributed to the use of superior heating stoves for heating the blast, known as Player's patent. There are large numbers of these excellent stoves at each of the above works. The blast is generally heated to about 1,200°, which is maintained with great regularity. The Norton furnaces were designed and built by John Player, an engineer of considerable experience, now residing in New York. The production of one of these furnaces is nearly 600 tons per week. The ores average 42 per cent.

The commercial value of the improved furnaces, as compared with the old style now obselete in Cleveland, is so great that upwards of 50 furnaces in good repair, are abandoned and will never be blown in again. Six years ago many furnaces "blew out," when pig iron reached 65s. per ton with labor and material cheaper than they now are; since then the large furnaces have been put at work and can sell pig iron at a profit at 40s. per ton. At many works in the United States, by remodeling and adding the Player stoves, results are now obtained that approximate nearly to those given in the large English furnaces; this is to be attributed to the superiority of the ores and fuel used here, more especially our admirable anthracite, than which there is no better fuel for the manufacture of pig iron, excepting of course charcoal, which is gradually becoming scarcer every year and is left out generally in calculations for a large continued business. There are also many instances among our American furnaces (to which we shall refer in detail on another occasion) of larger production and improved quality, due to the improved hot blast stove; the reduction of fuel in some instances is said to be 50 per cent with a corresponding increase in the production of the furnace and with the highest grade of iron where only ordinary iron was previously made.

The advantages of large furnaces (when suited to the materials) over smaller ones is so great that pig iron makers should no longer hazard the building of small furnaces; the difference in the cost of production in two years will clear the cost of the large furnace. From the results abroad, and the better practice just beginning here, it will

be seen that improvements actually exist, which, when fully applied to this industry in America, will revolutionize, not only the manufacture of pig iron, but the manufacture of cheap and good malleable iron and steel.

FLYING MACHINES.

PRINCIPLES—EXPERIMENTS—THE LIGHTEST STEAM ENGINE.

Condensed from a paper in the "Popular Science Review," by Fred. W. Brearey, Honorary Secretary to the Aëronautical Society of Great Britain.

In its normal state, the air is inapplicable as a power, but it is capable of becoming an overwhelming power, either by natural or artificial causes, as in the whirlwind and tornado or by rushing forcibly through it, as would be exemplified were the sails of a windmill rotated rapidly against it. Thus the bird may create for itself in a calm, by the agitation of its wing-surface, the power which supports and prolongs its flight in a horizontal or ascending line; but is also capable, in the calm of a sultry summer's day, by the mere momentum of its own weight, of gliding for an immense distance upon an unyielding plane, thus converting the inert air into a fulcrum or support. In such a case, two only of the three requisites for successful flight are brought into action, viz, surface and weight, the third, force, being held in reserve for extraordinary occasions.

There can be no question in dispute, as to the possibility of so manipulating and inclining the surface of a descending body, as to prolong the gliding motion, and convert it into one obedient in some degree to the will of the operator. When the two antagonistic forces, gravity and atmospheric resistance, are brought into operation, the result is a course, arrested and diverted in some direction, either by what we call accident, or design. Hitherto, as in the case of the parachute, accidental circumstances have alone determined the deviation. It has been the great desire of man for ages to supply, either in his own person, or by the aid of apparatus, or by self-acting machinery, the third requirement for flight, viz, force, which may enable him to impel a plane surface at the proper angle of inclination against the air, and thus to nullify the effect of gravity.

Necessarily, the relative proportion of sustaining surface to weight, and of power to uphold and propel that weight, have occupied much attention. Considerable misconception has existed upon these two points, and to this is mainly due the tardy progress of the science of aëronautics. In England, the subject has really never engaged the attention of scientific men, except under the form of aërostation, in the earlier years of its discovery. There have ever been persistent believers and experimenters, and in the influential association which has been organized under the name of the Aëronautical Society of Great Britain, embracing amongst its supporters some of the first scentific men of the day, with the Duke of Argyll as President, the subject of aëronautics has been elevated into a science.

In a paper by M. De Lucy of Paris, there is detailed the result of actual experiments made by the author, with a view of determining the extent of wing surface to the weight to be sustained, and of the force requisite to raise and impel in horizontal flight. The author asserts, that there is an unchangeable law, to which he has never found any exception, amongst the considerable number of birds and insects, whose weight and measurements he has taken, viz, that the smaller and lighter the winged animal is, the greater is the comparative surface. Thus in comparing insects with one another; the gnat, which weighs 460 times less than the stag-beetle has 14 times greater relative surface. The lady-bird which weighs 150 times less than the stag-beetle, possesses 5 times more relative surface, etc. It is the same with birds. The sparrow which weighs about ten times less than the pigeon, has twice as much relative surface. The pigeon which weighs about eight times less than the stork, has twice as much relative surface. The sparrow which weighs 339 less than the Australian crane, possessess seven times more relative surface, etc. If we now compare the insects and the birds, the gradation will become even much more striking. The gnat, for example, which weighs 97,000 times less than the pigeon, has 40 times more relative surface; it weighs 3,000,000 times less than the crane of Australia, and possesses relatively 140 times more surface than this latter, which is the heaviest bird the author had weighed, and it was that which had the smallest amount of surface, the weight being 20 lbs. 15 oz. 2¼ dr. avoirdupois, and the surface (referred to the kilogramme 2 lbs. 3.27 oz.) 139 square inches; yet of all traveling birds, they undertake the longest and most remote journeys, and, with the exception of the eagle, elevate themselves highest, and maintain flight the longest.

M. de Lucy remarks, that if the law of surface in inverse ratio to weight be regarded, the cause of all the errors which have been committed will be readily understood; for a mathematician who should select as his type an excellent bird of flight such as the swallow, by ascertaining its weight and surface, will apportion nearly one meter or 1,550 sq. in. to the kilogramme, and consequently 75 meters for a man of 75 kilogrammes, that is to say, about 165 lbs. would require a surface of 116,250 sq. in. Should he select the pigeon, he will arrive at a result quite different, because the pigeon being heavier than the swallow has a surface relatively smaller. According to this type, he would arrive at the conclusion that only 20 meters of surface or 31,000 sq. in. would be requisite for a man of the same weight. The example of the crane of Australia, would give to a man a surface of no more than 10,850 sq. in. Again, should he select a type amongst insects, for example the blue dragon-fly whose flight is so rapid, he would discover the weight to be rather more than $\frac{1}{2}$ grain, and surface nearly $\frac{2}{5}$ of a square inch, which referred to the selected standard of comparison would give 9,416 sq. in. and for the man 705,800 sq. in. Were we to determine the amount of sustaining surface requisite for the man from some of the butterfly tribe, whose wings are so prodigiously expanded in comparison with their weight, we should arrive at results so much in excess of these dimensions, that the construction of the apparatus would be impossible.

The author next proceeds to state that "The law of surface, in inverse ratio to weight, would naturally tend to lead us to this conclusion—viz: that the heaviest-winged animal, having the least surface, ought in return to possess the greatest force." But he proceeds to disprove this assumption, by showing, that the muscular force of insects is much greater than that of birds, and he adduces various well-known instances. Upon the supposition that his facts, and the theory founded on them, are correct, it will be a fair hypothesis to assume that where large wing-surface is given to insects, the provision is accompanied by the relative power to control it, in compensation for absence of weight, which we have seen is during descent a power of itself, and is taken advantage of by some birds, in gliding, or soaring against a breeze. For such purposes, weight is a necessity, and therefore we never see any similar method of flight in the winged insect tribe.

The first recorded and scientifically based attempt to connect plane surface and weight, in relative proportion to one another, was that of which all the world was cognizant in 1842, patented by Henson—a plan resulting from conversation between Henson and Stringfellow. "The amount of canvas or oiled silk necessary for buoying up the machine, was stated to be equal to one square foot for each half pound weight, the whole apparatus weighing about 3,000 lbs., and the area of surface spread out to support it, 4,500 square feet in the two wings, and 1,500 in the tail, making altogether 6,000 square feet." But this machine was never constructed; for after two abortive attempts to manufacture models, which should represent the dimensions before-named, the two inventors commenced their experiments under a variety of forms. Mr. Stringfellow frequently availed himself of the express train, taking with him an arrangement for testing the resistance of different angles against the air, at high speed, and he states that those experiments only tended to prove, that any guess-work was better than the calculations hitherto made by writers on the subject. In 1844, they commenced the construction of a model which measured twenty feet from tip to tip of wing, by three and a half feet wide, giving seventy feet of sustaining surface in the wings, and about ten more in the tail. The weight was from twenty-five to twenty-eight pounds.

An inclined plane was constructed, down which the machine was to glide, and it was so arranged that the power should be maintained by a steam engine, working two four-bladed propellers, each three feet in diameter, at a rate of 300 revolutions per minute. For seven weeks the two experimenters continued their labors. In the language of Mr. Stringfellow: "The machine was saturated with wet from a deposit of dew, so that anything like a trial was impossible by night. I did not consider we could get the silk tight and rigid enough. Indeed, the framework altogether was too weak. The steam engine was the best part. Our want of success was not for want of power or sustaining surface, but for want of proper adaptation of the means to the end of the various parts." Many trials by day down inclined wide rails showed a faulty construction, and its lightness proved an obstacle to its successfully contending with the ground currents.

Shortly after this, Mr. Henson left for America, and Mr. Stringfellow, far from discouraged, renewed alone his experiments. In 1846 he commenced a smaller model for indoor trial, and, although very imperfect, it was the most successful of his attempts. The sustaining planes were much like the wings of a bird. They were ten feet from tip to tip, feathered at the back edge, and curved a little on the under side. The plane was two feet across at its widest part; sustaining surface, seventeen square feet; and the propellers were sixteen inches in diameter, with four blades occupying three-fourths of the area of circumference, set at an angle of sixty degrees. The cylinder of the steam engine was three-fourths of an inch in diameter; length of stroke, two inches; bevel gear on crank shaft, giving three revolutions of the propellers to one stroke of the engine. The weight of the entire model and engine was six pounds, and with water and fuel, it did not exceed six and a half pounds.

The room which he had available for experiments did not measure above twenty-two yards in length, and was rather contracted in height, so that he was obliged to keep his starting wires very low. He found, however, upon setting his engine in motion, that in one-third the length of its run upon the extended wire, the machine was enabled to sustain itself; and upon its reaching the point of self-detachment, it gradually rose, until it reached the further end of the room, where there was canvas fixed to receive it. It frequently, during these experiments, rose after leaving the wire, as much as one in seven. He afterwards experimented with greater success at the Cremorne Gardens. Having now *demonstrated the practicability of making a steam-engine fly*, and finding nothing but a pecuniary loss, and little honor, this experimenter rested for a long time, satisfied with what he had effected.

In a paper read by Mr. F. H. Wenham, at the Society of Arts, on the occasion of a meeting of the Aëronautical Society, there occurred the following observation: "Having remarked how thin a stratum of air is displaced beneath the wings of a bird in rapid flight, it follows, that in order to obtain the necessary *length* of plane for supporting heavy weights, the surfaces may be superposed, or placed in parallel rows, with an interval between them. A dozen pelicans may fly one above the other, without mutual impediment, as if framed together; and it is thus shown, how two hundredweight may be supported in a transverse distance of only ten feet." Mr. Stringfellow having been again called out by the Aëronautical Society, eagerly grasped this idea and set about constructing the model which he exhibited at the Crystal Palace in 1868. This model contained in its three planes, a sustaining surface of twenty-eight square feet, besides the tail. Its weight, with engine, boiler, fuel and water, was under twelve pounds. It possessed in its steam-engine one third of the power of a horse, and its weight was only that of a goose. It will be seen, therefore, that the sustaining surface was more than two feet to the pound, always supposing that the system of superposing the planes, was efficiently represented in so small a model, which may reasonably be doubted. This proportion of weight to surface is more than double that which is generally allowed to be necessary. The necessity, however, for providing even for as little as one pound for every square foot, would not exist if a certain speed could be maintained.

It has been observed by several reporters for the press that the model showed a decided tendency to an upward course during its hundred yards run at the Crystal Palace, but upon farther trial, when freed from its support it descended an incline with apparent lightness, until caught in the canvas, but the general impression conveyed was this—that had there been sufficient fall, it would have recovered itself, and proceeded onwards. Subsequently, Mr. Stringfellow lengthened the propellers, and added nine feet to the central plane, which, with other alterations, decidedly deteriorated its aërial capabilities. He is now engaged in experimenting with a view of ultimately constructing a large machine that would be sufficient to carry a person to guide and conduct it. On this scale he would avoid many difficulties which are inseparable from small models.

As Mr. Stringfellow gained the prize of £100 for "*the lighest steam-engine in proportion to its power*," and as the engine which propelled the model at the Crystal Palace differed from that but in dimensions, we append a description of the engine, which was given in the report upon Exhibition published by the Aëronautical Society: "The steam engine does not differ from an ordinary one, except in the precautions to ensure lightness. The two-inch cylinder is of very thin brass tube; the covers, flanges and glands are also as light as can be made, consistently with

strength; the ports and passages are in one separate piece, screwed on; the piston-rod passes through each end of the cylinder, and by means of long connecting rods, works in opposite directions two cranks, fitted to the axes of two four-bladed screws, three feet in diameter; two light bars extend from the crank-shaft down each side of the cylinder: these sustain the thrust of the piston, and a framing is thus almost dispensed with. The boiler consists of a number of inverted cones, made of very thin sheet copper, with the joints soldered with silver solder. Each cone is closed with a hemispherical cap. The cones are placed in parallel rows; the bottom ends, or apexes, of the series are all connected together by water-tubes; and from the hemispherical tops a small steam pipe conveys the steam away to a cylindrical chamber above the system: this is set in the smoke-box, and serves as a super-heater, and the steam is quite dried therein. The cones are not liable to prime, as the water surface for the escape of the steam is extensive, and the steam rises clear from the generating surfaces. The fire space between the bases being large and free, this form of boiler is particularly well adapted for burning liquid fuels. The cylinder is two inches in diameter, stroke three inches, boiler pressure 100 lbs. per square inch. The engine makes 300 revolutions per minute. In three minutes after lighting the fuel, the pressure was 30 lbs.; in five minutes, 50 lbs.; and in seven minutes its full working pressure of 100 lbs., driving two four-bladed screw propellers, three feet in diameter, at 300 revolutions per minute.

In an article entitled "Swimming or Flying," contributed to the "Times," (April 9, 1868,) the author comments upon the possibility of man's sustaining himself by his own muscular exertion, and especially refers to Mr. Charles Spencer's assertion that he could not only effect this feat, but that he could sustain flight for several yards. Mr. Spencer constructed an apparatus, and by its means he avers that he has proved, that 110 square feet properly disposed, is sufficient to sustain 158 lbs. weight. With such an apparatus, composed of plane and wings, he states, that running down a small incline in the open air, and jumping from the ground, he has by the action of the wings, sustained flight to the extent of 120 feet. The framework of this apparatus, was a marvel of lightness and strength, compsed of steel umbrella wires and wicker-work. Length of tail, 18 ft.; width at the end, 8 ft.; depth of keel at the end, 4 ft.; weight of tail, 15 lbs.; area of tail, 72 sq. ft. Length of wing, 7 ft.; width at the widest part, 4 feet; area, 15 sq. ft.; weight, 1½ lb.; weight of the whole—tail 15 lbs.; wings, 3 lbs. = 18 lbs.; weight of himself, 10 stone, and sustaining surface, 110 sq. ft.; total weight of himself and apparatus, 158 lbs.; making not quite 1½ lb. to the square foot. Owing to the wicker-work—which is made to fit tight round the body—causing pain, and otherwise obstructing his movements, he was unable to satisfy the curiosity of the public, and he is now reconstructing that portion, and substituting a stronger material for the covering. According to De Lucy's theory of surface in inverse ratio to weight, the sustaining surface, instead of being 110 square feet, need only have been about 31 square feet, always supposing that the surface was effectively disposed, which in Spencer's apparatus may be very properly questioned.

We come now to the description of another—Gibson's machine. Dissimilar to either of the former inventions, which respectively consisted of plane—and plane with wings—this was expected to obey the action of the wings alone. The mechanical action at the command of the operator was intended to be controlled by the downward pressure of each leg alternately, assisted by the arms. The machine therefore consisted of a framework, to which were attached four wings, so that by pressure upon one treadle, two flew up feathered, and two descended with an impact upon the air.

In a previously constructed apparatus provided with two wings only, Gibson states that a man weighing 10½ stone repeatedly raised himself from the ground from 12 to 18 inches, but that he could not sustain himself, because the wings being so heavy, he was not able to repeat the stroke. Each wing was 12 feet long, 1½ feet across at the wider part, and 1 foot at the narrower; surface of both wings 37 square feet; weight of each wing, 10 lbs.; frame and rods, 21 lbs.; weight of man, 10½ stone; giving about 5 lbs. to each foot of sustaining surface, a condition which severely tests the theory of inverse proportion of surface to weight. The four-winged contrivance sent to the Crystal Palace was found to be too heavy for trial, but the inventor's enthusiasm seems to be quite equal to the construction of another and lighter apparatus for further exhibition. It must be remarked, as an inter-

esting feature in Gibson's apparatus, that the total weight of the man and apparatus, as compared with the surface, gives on De Lucy's theory, about 38 square feet as the proper sustaining surface, or one foot more than it possesses—taking for our calculations, the Australian crane, and the theory of inverse proportion with its margin of from eight to ten times.

Experiments can alone determine the true path to success, and it is encouraging to find that these are now aiding in the determination of the question. It is possible that we may shortly witness some more advanced attempts, and should they prove to be failures in the practical solution of the problem, it will perhaps be remembered that previous failures having led to increased knowledge, so future success may result from their repetition.

IMPROVED GAS-HEATING FURNACE.

ESTIMATE OF THE QUANTITY OF FUEL REQUIRED FOR CAST STEEL, WITH THE SIEMENS FURNACE, AND BY THE NEW PROCESS OF PARTIAL ELIMINATION OF NITROGEN, OF M. CH. SCHINTZ, OF STRASBOURG.

Translated from "Le Génie Industriel."

We announced in our last number the appearance of a work of M. Schintz, on the High Furnace. Before giving an analysis of it, as we promised, we believe our readers will be interested in the following analysis upon a kindred subject, which M. Schintz has kindly communicated.

In the "Oestreichichen Zeitschrift für Bergüttenmanner," No. 26, 1868, M. Kupelwieser, Professor in the School of Mines of Leoben, showed that the expense of fuel in the production of steel, by the Martin process, does not greatly exceed that by the Bessemer. This is surprising, in view of the fact that the intense heat by the latter process is produced by the small percentage of carbon in the gray metal, while in the Martin process, as at present conducted, the operation lasts seven or eight hours, and consumes at least 1.5 kilogrammes of lignite for every kil. of steel produced. Although the consumption by the latter process is so great, the small ultimate difference between the two is due to the fact that for the Bessemer, gray iron is used, and for the Martin, white iron, and the production of the latter, in the high furnace, requires but one-half to one-third the quantity of coal necessary for the former.

I have found the computations of M. Kupelwieser quite accurate, though I by no means agree with him when he undertakes to show that the regenerating furnace of M. Siemens is preferable to all others for the Martin process; for it is easy to demonstrate the reverse. I have before me the plan of a reheating furnace, on the Siemens plan, which ought to consume pretty nearly as much fuel as a cast steel furnace; the only difference being that the latter is only about half as long. A charge for the steel furnace is composed of

.888 kil. white pig,
.664 kil. puddle bar and crude steel, } 1.552 kil. = .21555 c. meters of casting.

.47 kil. ore, . . . pure and rich, which is decomposed into FeO and CO—. Volume of the CO 1.5 cubic meters.

Assuming that the melted metal is .15 m. thick, the surface will be $\frac{.21555}{.15} = 1.437$ sq. met., and allowing .5 m. for the breadth, the length will be $\frac{1.437}{.5} = 2.8$ met. But in the Siemens furnace we must add the bridges which hold the metal, the flues which conduct the gas, and the air and the flues at the other end which lead off the products of combustion. All this augments the length of the melting furnace, and gives us, instead of 2.8 m., a length of 4.2 m., and the exterior surface of the arch and side walls becomes 10 sq. m., while without these necessary accessories this surface would be but 3.42 sq m. Now, making all due allowance for what takes place in the regenerators themselves, their use is a source of great loss of heat, for we have just shown that the loss of heat by transmission is excessive, compared with the useful effect. The transmission for a unit of surface, per hour, is

$$t' = \frac{T - t''}{1 + Q\frac{e}{c}} + t''Q.$$

T being the temperature of the furnace; t'' that of the atmosphere

$$Q = \frac{S\,m\left(\frac{t}{a-1}\right)a\,l + L\,u\,t^{a}}{t}$$ (formula of Dulong).

$S = 3.62$, $L = 1.988 = 20°$, $e = .2$, $c = 0.8$ at least, $e =$ thickness of walls, $C =$ the conductibility of the materials of which the walls are composed.

M. Ed. Becquerel has found that the melting point of decarburized iron is between 1,350° and 1,400° Cent. There is no probability that the temperature of the furnace exceeds 1,400° C., otherwise the operation would not last seven or eight hours. Supposing, then, that $T = 1{,}400°$ and $t'' = 20°$, the theoretical transmission is $\frac{1{,}400 - 20}{1 + Q\frac{2}{3}} + 20\,Q = 4{,}892$ calories ($Q = 17.92$). My own researches have shown that the actual transmission of heat is from three to thirteen times greater (according to the temperature) than the theoretical transmission, for the surrounding air being always in movement, and becoming warm, carries off great quantities of heat. The effective transmission in this case cannot fall short of 134,892 = 63,596 calories per sq. met. per hour. For 10.24 sq. m. this becomes 651,223 calories. But we must remember that the value of L in the formula of Dulong is less for a horizontal than for a vertical surface. We must, therefore, deduct one-third upon two-thirds of the calculated transmission, which amounts to 71,501. Deducting this 651,223 — 71,501 = 579,722 calories.

To melt one kil. of decarburized iron the heat consumed is 1,400 × .16585 (.16585 being the specific heat of iron at 1,400°) = 232 calories. Latent heat of fusion = 160 + (.16585 — .11379) 1,400 = 233 calories. Total heat consumed in melting one kil. of iron, 465 cal., and for 1,552 kil., the entire charge 465 × 1,552 = 721,680, and per hour, allowing eight hours for the operation, $\frac{721{,}680}{8} = 90{,}210$ cal., which, added to the transmission above calculated, gives for the number of calories employed in the furnace of fusion, 669,932.

The fuel employed at Leoben was lignite, of which the calorific power is 5,419 calories per kil. for a perfect combustion, and on the supposition that the gas arrives in the furnace at the temperature it gets in the generator. It is known that in the Siemens furnace it is necessary to cool the gas and condense the hydro-carbon vapors, because if they get into the regenerator they are decomposed there, and give off a deposit of carbon which obstructs the flues; but as the heat so lost is restored by the regenerator itself, we may consider the gas as being in the same condition as if it had not been cooled. Hence, the pyrometric equivalent of the lignite, for a furnace temperature of 1,400°, is 5,419 — 1,400×2.15525 = 2,402 calories, and the quantity carried off per kil. of lignite = 3,017 calories. Dividing the consumption of heat in the furnace by the pyrometric equivalent, we obtain $\frac{669{,}932}{2{,}402} = 279$ kil. of lignite necessary for this consumption. But the actual expense is 291 kil., and thus there remains an excess of 291 — 279 = 12 kil., showing that a portion of the gas is not burned in the furnace, but in the regenerator. The same thing may be seen taking place in the largest glass furnaces, which are six to eight meters long, and I have noticed that there is always some flame at the end of the fire circuit, which proves that the gas is burned gradually. The result is, that in the Siemens system the gas and air are not thoroughly enough in contact to make a perfect combustion. If, now, the length of fire circuit, for accomplishing approximately the same result, is only four meters, it need not surprise anybody if the combustion is completed in the regenerator. The following are the quantities of heat which the regenerator receives per hour:

279 kil. lig. at 3,017 = 841,733 } = 906,771
12 " " 5,419 = 65,028 } calories.

The capacity of the four chambers of the regenerator is 42,336 cubic met., of which $\frac{1}{3}$ is of solid fire-brick, =14,112 cubic met. at 1.9 [specific gravity] = 26,812 kil., and the capacity for heat = 26,812 × .24 = 6,435 calories.

The maximum of heat in the regenerator, when the products of combustion cease to pass it, is

Entrance temp. $= \frac{906{,}771}{291.\ 2.15525} = 1{,}446°$.
Exit temp., ... 300°.
Mean, ... 873°.

Maximum capacity 873×6,435 = 5,617,755 cal.

It is at the minimum, just after the air and gas have ceased to pass, and hence it is minus the heat introduced per hour, which is, as above, 906,771, making 5,617,755 — 906,771 = 4,710,984 calories, and the mean temperature of this regenerator is not above $\frac{4{,}710{,}984}{6{,}435} = 732°$.

The exterior surface of the regenerator

measures 46.02 sq. met., the thickness of the walls is $e = .3$, their conducting power at least $.6 = c$. Hence the mean temperature regulating the transmission is $\frac{873+732}{2}$ $= 802°$, and the theoretic transmission becomes $\frac{802-20}{1+Q:\frac{3}{6}} + 20\ Q = 1{,}537$ cal.

The actual transmission is 7,753 calories, and the total

	Calories.
Transmission $= 46.2 \times 7{,}753 =$	358,188
The loss by escape, $300 \times 291 \times 2.15815 =$	188,100
Useful effect, ...	360,483
Total heat equal to that introduced, ...	906,771

The quantity of heat lost by the gas in cooling is 303,804 calories. Hence all the gain we get from the regenerator is 56,679 calories—just enough to raise the temperature of the air to 289°.

These calculations are the results of a system of long continued and very careful experiments, and are perfectly in harmony with the facts, for if the temperature of the furnace is higher than the melting point of the metal, the operation would be complete in much less time than seven to eight hours.

I have proved, by the formula of Cauchy, that supposing the metal to be penetrated with a volume of carbonic oxide equal to its own, while the bed of coal is $2 \times .15$ met., the conductibility will be such that in a few minutes the mass will take the temperature of the furnace. Now, to produce steel much more cheaply than by the Bessemer process (which leaves a great deal to be dedesired on the score of certainty of quality in the product), we should have to devise a method of heating which would admit of a higher temperature. It need not necessarily be very much higher—in fact an addition of 100° would probably be sufficient to reduce the length of the operation one half, and hence, even supposing the quantity of fuel burned per hour to be the same, there would still be an economy of one-half the fuel, of labor, interest on capital, etc. We shall proceed then to show that it is practicable to increase the heat of the furnace at a smaller expense of fuel.

This method consists essentially in the production of a gas which contains a smaller proportion of nitrogen than is usual in processes now employed.

To produce this gas we may decompose by heat carbonate of lime, and pass the carbonic acid given off over coal dust or some substance containing carbon. This will give us pure carbonic oxide. By burning this with the quantity of air necessary to reproduce the carbonic acid, and effecting this operation within a combustible solid, which will again reduce the $C\ O_2$ to $C\ O$, this last product will be mixed with only one-half the volume of nitrogen which ordinarily accompanies the gas produced by combustion. The pure oxide of carbon will have, on leaving the chamber in which it is produced, a temperature of 1,000°. For every kil. of carbon which it contains it will yield 2,400 calories, to which we must add $1{,}000 \times .2479 \times 2.333 = 578$ cal. If the air used in the combustion is introduced at 300°, it adds $300 \times .2377 \times 5.7515 = 410$ cal., which, added to the foregoing, is 3,388 cal. On the other hand, the reduction of the carbonic acid produced, absorbes 2,400 cal., and deducting this the quantity of heat contained by the gas will be 988 cal. This gas is composed of

4.6666 k. $C\ O$ whose spec. heat	$= 1.1568$	1.9966
3.4418 k. N whose spec. heat	$= .8392$	

The temperature of the mixture will therefore be $\frac{988}{1.9966} = 495°$. The burning of 4.6666 k. of $C\ O$ in the furnace will yield

	Calories.
4.6666×2400, ... $=$	11,200
The gas brings with it, . . . $=$	988
The air at 300° brings $11.5030 \times 300 \times .2377$, ... $=$	820
Total, ...	13,008

The products are

7.3333 k. $C\ O_2$ spec. heat,	1,587	4,160
10.5458 k. spec. heat,	2,573	

and the initial temperature is $\frac{13{,}008}{4{,}160} = C$ $.3127°\ C$.

For 1 kil. of lignite (allowing that $\frac{1}{3}$ kil. of carbon is absorbed by the carbonic acid given off by the carbonate of lime, which contains 0.20565 k.) there will be required

1.7136 k. carb. lime, . . .		20,563 cal.
3333 / 6667	1.0000 lignite, . .	20,563 " / 41,126 "

and we have $.41126\ C = 95061\ C\ O$, which requires $.54855\ O + 1.8171\ N = 2.236545$ kil. of air, and becomes 1.50796 k. $C\ O_2 +$

1.8171 *N*. To reduce again this $C\,O_2$ to *C O*, will take .41126 *C*. contained in 0.6667 k. of lignite, —0.6667 k. lignite containing 0.41126 k. calories, 0.17994 elements of water, 0.01346 free hydrogen. So we shall have in the gas produced

kil.		kil.
1.91992 *C O*,	which requires	1.0967 *O*
.01346 *H*,	" "	.10768 *O* = 3.9908 *N*
.17994 *H O*,	" "	1.20438 *O* k.
1.8171 *N*,	" "	5.19018 air=5.1918 air

The gas produced by *C* and *Ca O*, *C* O_2, receives in the chamber where it is produced the temperature of 1000°, and consequently brings $1000 \times .95961 \times .2479 = 238$ cal.
The air to be burned with it, $300 \times 2.36545 \times .2377$, . . = 168 "
Total,. . . . . 406 "

The production and absorption of heat by the reduction cancelling each other, need not be carried forward in the account, but there will be .17994 *H O* to evaporate, which will take $.17994 \times 536.67 = 96$ calories to be deducted, leaving in the gas 310 cal.

The following is the composition and specific heat of the gas:

k.				
1.91922 *C O*	× .2479	= .4757	}	1.0504
.01346 *H*	× 3.4046	= .0458		
.17994 *H O*	× .475	= .0855		
1.8171 *N*	.244	= .4434		

Hence the temp. will be $\frac{310}{1.0504} = 295°$ C.

By burning this gas in the furnace we produce

k.		cal.	cal.	
1.91922 *C O*	at	2400	= 4,606	} 5743 cal.
.01346 *H*	at	34000	= 457	
5.19518 hot air	at	300	= 370	
Brought in by the gas			310	

The specific heat of the product is

k.				
3.01592 *C* O_2	0.2164	= .65262	}	2.21273
.30108 *H O*	.475	= .14301		
5.8079 *N*	244	= 1.41710		

The initial temperature $= \frac{5743}{2.21173} = 2596°$ C. The pyrometric equivalents for the following temperatures will be

For	1400°	1450°	1500	1550
Pyr. Eq.	2645	2535	2424	2314 cal.
Heat passing off,	3098	3208	3319	3429 cal.

Hence it appears that the same weight and kind of fuel will produce a furnace temperature of 1500°, while without the elimination of nitrogen it would give but 1400°. It now remains to see whether the heat passing off from the furnace will be sufficient to decompose the carbonate of lime, and to reduce the carbonic acid formed to carbonic oxide.

For the same dimensions of the furnace proper the area of the arch and walls reduces to 3.42 sq. met., because we no longer need the entrance and exit flues, nor the bridges for holding the melted metal. If we suppose the times corresponding to temperatures to be as follows,

Hours,	8	$6\frac{1}{2}$	5	$4\frac{1}{2}$
Temp.,	1400	1450	1500	1550

we shall not have exaggerated the advantage, which gives us as useful effect, per hour,

$$\frac{721680}{8} = 90210$$
$$\frac{721680}{6.5} = 111028$$
$$\frac{721680}{5} = 144336$$
$$\frac{721680}{4.5} = 162573$$

Observing that this arch is one-half the whole surface, and using the same notation as before, we shall find the actual transmission, per square meter, per hour, to be

	47697	49187	51114	Cal. 53109
and for 3.42 sq. m.....	163123	168219	174810	181633
Useful effect ..	90210	111028	144336	162573
Total heat ..	253358	279247	319146	344206

These figures, divided by their pyrometric equivalents, give for the expense of fuel per hour

96 110 132 149 kil. lignite,

and the quantities of heat passing off,

297408 352880 438108 510921 cal.

For 1 kil. lignite we must decompose 1.7136 kil. of carbonate of lime, which requires, in order to be heated to 1000°

$1.7136 \times .675083 \times 1000 =$.	1157 cal.
Heat of combination 1.7136×251	430 "
Heat of $C\,O_2$ first formed . . .	1587 "
Heat to reduce it to *C O* . . .	493 "
Total, ...	2080 "

And for the calculated weight of fuel
199680 228800 274560 309920 cal.

Leaving the heat to pass off
97728 124080 165548 201001 cal.

The weight of $Ca\ O\ C\ O_2$ to be decomposed per hour is

164 188 226 255 kil.

and as it takes two hours to effect the operation at 1000°, the volume of it will have to be double,

.246 .285 .338 .382 sq. met.

The height of the chambers being one meter, their length, in order to contain these quantities, must be

.5 .6 .7 .8 met.,

and it will require two chambers in order that one may be working while the other is being charged.

The chambers containing the carbon for reducing the $C\ O_2$, which is given off by the lime, should be as large as practicable, in order to avoid the necessity for frequent charging, and allowing for height one meter, and breadth .25 met., we propose to give the lengths

1.2 1.5 1.4 1.5 met.,

and the following number of the chambers,

3 3 4 4

We have seen that the gas produced in the generators receives the temperature only of 295°, which is not enough to effect a perfect reduction, but by surrounding the generators with products of combustion at 1000°, we can effect a perfect, which is a matter of great importance. By making two generators .8 met. long, .8 high, and .45 wide, we can arrange them in the furnace with the necessary chambers, in such a manner that the latter will present a minimum surface of 15.97 sq. met., and a maximum of 20.66 sq. met., and allowing a thickness of wall of .5 met. $= e$, and a conductibility $c = .6$.

Then the theoretic transmission, per sq. met., per hour, will be

$$\frac{1000° - 20}{1 + Q\frac{5}{6}} + 20 \times 10.197,$$

and the actual transmission four or five times greater, ... = 5722 cal.

Total maximum transmission 2066×5722 . . } = 118216 "

Total minimum transmission 1597×5722 . . } = 91380 "

while the quantities at our disposal are, maximum, 201001 cal.; min. 97728 cal.

Hence the quantity of heat passing out of the fusion furnace is more than sufficient for the production of the carbonic oxide.

If the assumptions we have made as to the relative time of fusion are correct, which is very probable, the consumption of fuel for one kil. of steel will be

$\frac{96 \times 8}{1552} = 0.495$ k. $\frac{110 \times 6.5}{1552} = 0.461$ k.

$\frac{132 \times 5.5}{1552} = 0.425$ k. $\frac{149 \times 4.5}{1552} = 0.431$ k.

lignite, while by the furnace at Leoben it is $\frac{291 \times 8}{1552} = 1.5$ k.

ORIGIN OF FORCE—WEIGHT NO FORCE.—Gravitation, acting in the direct ratio of the mass of bodies, gives us a direct measure of this mass by the weight. As a unit of this weight the pound has been adopted, and the expression of a certain number of pounds affords us, therefore, a tolerably definite notion of the amount of matter with which we have to deal. When, now, by the removal of obstacles, gravitation is allowed to produce motion, this motion, must accelerate as long as gravitation continues to act in the direction in which the body is moving. The motion thus produced by gravitation is called an accelerated motion; but gravitation is not necessarily an accelerating force. It may act as a retarding force, when the body moves in an opposite direction, as, for instance, when a stone is thrown upward. In fact, gravitation may result in an accelerating force, in a retarding force, or (in case there is no opportunity for the body to be brought into motion) in no force at all.

But to return: a body is put in motion by gravitation only; it falls, and there is a force generated, which increases in proportion to the space through which the body falls. This space, again, is proportional to the square of the time that gravitation acts, according to the well-known law of falling bodies. Suppose, now, that this motion, after being produced by gravitation, is totally or partially destroyed by resistance, heat will be produced. Direct experiments have demonstrated this to be a permanent fact. By modifying the circumstances, electricity, light or magnetism may be produced or apparently generated; and we may therefore look upon gravitation as the prime source of all other forces. In the same manner as we cannot destroy the motion of a leaden ball, falling only from

the height of a few feet on the floor, without observing a remarkable increase in the temperature, so any cosmical matter, falling toward a center of attraction (the sun), must, at reaching that center, where its motion is destroyed, cause a rise in temperature, of an intensity proportional to the weight of matter, and to its final velocity. When the masses are thousands of millions of tons, and the distance through which they fall thousands of millions of miles, and consequently the velocities enormously great, the resulting rise in temperature must necessarily be far beyond our conception. This is, in fact, the modern modification of the celebrated nebular theory of La Place.

When gravitation is prevented from producing motion, no equivalent of heat can be produced by the destruction of motion, as there is no motion; and, as all force can be expressed by an equivalent number of units of heat (one unit of heat being 770 units of force or foot-pounds), it becomes at once self-evident that the simple weight of bodies, as it can not be expressed in terms of heat, can not and must not be considered as expressing anything like a force. It must, therefore, not be used in a sense conveying the thought that a ponderable body of a certain weight can represent a force. The defective but common use of language, in mentioning forces of so many pounds, hundredweights or tons, should give way to the more accurate ideas of modern science. Reform in this direction will be much easier than at first appears.—*American Journal of Mining.*

HOLLOW VS. SOLID SHAFTING.—Hollow shafting, where large diameter is not objectionable, has long been in use, made generally of cast iron, and frequently used as a drum or continuous pulley for the reception of belts. Such a shaft was used in the "pistol shop" of Colt's factory before the destruction of the building by fire about four years ago, and a similar line may now be in use in the reconstructed building. This shaft was five hundred feet long and fifteen inches diameter, made of hollow cast-iron cylinders, connected with each other by a solid shaft or bearing at each end, resting in a box as a journal. The result was an almost continuous drum, of five hundred feet in length, from which belts led to the counter shafts of the machines, the speed of each machine being regulated by the diameter of the pulleys on the counter shafts. We have heard also of wrought iron pipes of only two inches diameter being used as shafting successfully.

Tredgold says that a round tube whose internal and external diameters are as seven to ten, respectively, has twice the lateral strength of a solid cylinder containing the same amount of material. A cylinder (solid) of cast iron, five inches diameter, has a transverse strength of 21,104 pounds, while one of eight inches diameter, containing the same cross sectional area of metal, has a transverse strength of no less than 45,416 pounds.

These facts would seem to show plainly the possibility of reducing the weight, materially, of shafting, without a diminution of its strength. The weight of shafting is a mass, the inertia of which must be overcome by the driving power, and in some cases the amount of power, otherwise useful, that is thus absorbed, is not less than twenty per cent. If by the use of lighter shafting this could be reduced only five per cent, the saving would be worth an effort. Shafting must be of sufficient diameter to sustain the weight of pulleys and the strain of belts without springing, but if the requisite stiffness—resistance to torsion and springing—can be obtained by hollow shafts of much less weight, not only is money saved in the first cost (shafting being furnished by the pound), but the continual expense in the absorption of unnecessary power in driving the unnecessary weight would also be prevented. That hollow shafting of wrought iron can be made cheaply is sufficiently apparent when we examine specimens of pipe used for various purposes. And not only would the first cost be less, but the ease of handling, owing to reduction in weight, would lessen the cost of turning, etc. Such shafting could also be easily oiled from the inside, which would seem to be the proper method.—*Scientific American.*

HARTMANN'S LOCOMOTIVE WORKS.—Mr. Richard Hartmann has recently added to his large works at Chemnitz, Saxony, a locomotive erecting shop, with lines for thirty-five engines. This shop is 466 ft. long, and 120 ft. wide. The shop for lathes and machine tools, which has been some three or four years at work, is 450 ft. by 90 ft. Mr. Hartmann now employs 2,300 workmen. They are chiefly employed upon locomotives and machine tools. When the business in textile fabric machinery is fairly prosperous, 500 more workmen are employed.

WIRE ROPE TRANSPORT SYSTEM.

"Mechanics' Magazine."

A novel use of wire ropes has recently been patented and put into practice by Mr. Hodgson, C. E., having for its object the construction of light and cheap ways for the transport of mineral or agricultural produce in localities as yet unprovided with railways. Though a great number of cases exist in Great Britain to which it may be applied with advantage, the chief development of this method of carriage will probably take place in the colonies, and in other countries which stand in urgent need of light lines of some kind to convey their productions to the main arteries of inland communication, or to ports. The system may briefly be defined as a continuous development of the plan now not unusual in India, Australia, and in some mining districts, of bridging over a river or ravine by a single wire rope, by which, carried in a bucket suspended by a pulley, the necessary loads are transmitted from one point to another.

To accomplish the easy passing of the points of support necessary to carry out a continuous line of communication, and to provide for the distribution of the burden and the application of motive power, have been problems of no small difficulty; but, after experiments on a first trial length of half a mile, during the autumn of last year, these practical details were worked out, and a contract was immediately entered into for a line of three miles in length at Bardon Hill quarries, belonging to Messrs. Ellis and Everard, near Leicester, which has recently been completed, for mineral traffic. The practical working of this line was recently tested in the presence of a number of engineers and gentlemen interested in the question, when it was found to work well, and to answer its purpose admirably. This line consists of an endless wire rope, supported on a series of pulleys carried by substantial posts, which are ordinarily about 150 feet apart, but, where necessary, much longer spans are taken, in one case amounting to nearly 600 feet. This rope passes at one of its ends round a Fowler's clip drum, worked by an ordinary portable steam engine, and the rope is thus driven at a speed of from four to six miles an hour. The boxes in which the stone is carried are hung on to the rope at the loading end, the attachment consisting of a pendant of peculiar shape, which maintains the load in perfect equilibrium, and at the same time enables it to pass the supporting pulleys with ease.

Each of these boxes carries 1 cwt. of stone, and the delivery is at the rate of about 200 boxes or ten tons per hour for the three-mile distance. It is almost unnecessary to observe that the proportions of such lines can be varied to any extent to suit the requirements of any particular trade, ranging from 10 tons to 1,000 tons per day.

In the case of lines for heavy traffic, where a series of loads, necessarily not less than 5 cwt. to 10 cwt. each, must be carried, a pair of stationary supporting ropes, with an endless running rope for the motive power, will be employed, but the method of supporting, and the peculiar advantage of crossing almost any nature of country with a goods line without much more engineering work than is necessary for fixing an electric telegraph, without bridges, without embankments, and without masonry, exists equally in both branches of the system. The cost of establishing these lines will vary considerably in proportion to the quantity they are required to carry, but from their peculiar construction their cost will vary very slightly in relation to the nature of the ground which they may traverse.

The most important feature in Mr. Hodgson's invention is his method of passing the points of support. Both in lines like that now in operation, where the rope moves, and in those in which it is proposed to have a standing rope separate from the propeller, the stability of the load is obtained by curving in the frame of the carriage till the centre of gravity comes under the rope. The overhanging of the rope is of course essential in this case. Nothing can be more satisfactory than the working of the present three mile line, which stamps it as a practical invention, and which we hope will lead to its adoption wherever the necessity for such an appliance exists.

BURNING LIQUID FUEL.—Another system has been, after long experiment, put in regular and successful operation by Mr. A. Smith, Stratford, England. The creosote is stored in an underground tank outside the engine-house, from which it is forced up by steam pressure into a reservoir, also outside the engine-house, and to which is attached a float and a graduated scale, by which the consumption of oil is ascertained. A supply pipe from the cistern, with a regulating cock is turned into the tube of each of two

Cornish boilers, 18 ft. long, 5 ft. diameter, with flues 2 ft. 6 in. in diameter. The oil supply pipe projects about 9 in. into the boiler tube, the mouth of which is simply covered by a plate of thin sheet iron, which is raised or lowered to regulate the draft. Into the oil tube is turned a smaller tube carrying the superheated steam, which issues from small apertures at its nozzle. The creosote is thus driven into the furnace with great force, being broken up into the finest spray, and forming a powerful flame, which impinges upon a heap of brick core in the tube which is maintained at a red heat.

From the single jet, steam is easily kept in each of these boilers at a constant pressure of 55 lb. to 60 lb., which is supplied to two engines for driving the machinery. One of these engines is a 10-horse power horizontal; the other, a 30-horse power beam engine. Besides the two boilers already mentioned, there is a third of the same dimensions, in which steam is kept up by the waste and refuse produced in the factory, the steam being used only for heating purposes, and not for the engines. This boiler is always going, and in the morning supplies steam with which the creosote furnaces are started.

The consumption for the two boilers is seven barrels of thirty-six gallons each per day of 12 hours. Taking the cost at the fair price of 1d. per gallon, we have only £1 1s. per day, or 10s. 6s. for each boiler. Mr. Smith's consumption of coal used to be $2\frac{1}{2}$ tons per day—a great contrast in point of expense to his present working. Then, there is a further saving in attendance, a boy being well able to do all that is necessary, whilst there is no clinkering, nor are there any fire-bars to burn out. Altogether, a great economy is realized, and much credit is due to Mr. Smith for the simplicity and efficiency of his invention.—*Mechanic's Magazine.*

THE "ZIRCONIA" LIGHT.—The specification of Messrs. Tessie du Motay & Co. for improvements in oxyhydrogen light, is as follows:

"Zirconia, or oxyd of zirconium, in whatever manner it may be extracted from its ores, can be agglomerated by compression; for example, into sticks, disks, cylinders, or other forms suitable for being exposed to the flame of mixtures of oxygen and hydrogen, without undergoing fusion or other alteration. Of all the known terrous oxyds, it is the only one which remains entirely unaltered when submitted to the action of a blowpipe fed by oxygen and hydrogen, or mixtures of oxygen with gaseous or liquid carbonated hydrogens. Zirconia is also, of all the terrous oxyds, that which, when introduced into an oxyhydrogen flame, develops the most intense and the most fixed light.

"To obtain zirconia in a commercial state I extract it from its native ores by transforming, by the action of chlorine in the presence of coal or charcoal, the silicate of zirconium into double chloride of zirconium and of silicium. The chloride of silicium, which is more volatile than the chloride of zirconium, is separated from the latter by the action of heat; the chloride of zirconium remaining is afterwards converted to the state of oxyd by any of the methods now used in chemistry. The zirconia thus obtained is first calcined, then moistened, and submitted in molds to the action of a press with or without the intervention of agglutinant substances, such as boracic acid or clay. The sticks, cylinders, disks, or other forms thus agglomerated, are brought to a high temperature, and thus receive a kind of tempering or preparing, the effect of which is to increase their density and molecular compactness.

"I can also compress in molds shaped for the purpose a small quantity of zirconium capable of forming a cylinder or piece of little thickness, which may be united by compression in the same mold to other refractory earths, such as magnesia and clay. In this manner I obtain sticks or pieces of which only the part exposed to the action of the flame is of pure zirconia, while the remaining portion which serves as a support to it is composed of a cheap material.

"The property possessed by zirconia of being at once the most infusible, the most unalterable, and the most luminous of all the chemical substances at present known when it is exposed to the action of an oxyhydrogen flame, has never before been discovered, nor has its property of being capable of agglomeration and molding, either separately or mixed, with a small portion of an agglutinant substance."—*Chemical News.*

NAVAL BUREAU OF STEAM ENGINEERING.—The appointment of Mr. King in place of Mr. Isherwood as chief of this department, will close the era of experiments, and inaugurate, it is to be hoped, the safe practice of following good examples.

BUTT-JOINTED BOILERS.

From "Engineering."

For some time past several of our leading locomotive engineers have been in the habit of making the boilers of the engines constructed by them with butt-jointed longitudinal seams, provided with both inside and outside covering strips. No doubt those employing this form of joint, consider it—and very justly—to be a good one; but, judging from the proportions of the riveting frequently used in connection with it, we believe that in many cases its merits are far from being fully appreciated. Our reasons for this opinion may be explained very briefly. In the case of what we may term an "ordinary" riveted joint—as, for instance, a lap-joint, or a butt-joint with a covering strip on one side only—failing by the shearing of the rivets, this shearing takes place at one point only of the length of the latter, whilst in the event of a butt-joint with covering strips on both sides failing in a similar way, each rivet will be sheared at two points. In other words each rivet is in the last-mentioned joint in a state of "double shear," as it is sometimes called, and therefore exposes twice the resistance that a rivet of the same size would offer in, what we have termed for distinction, an "ordinary" joint.

Taking this fact into consideration, it follows that in a butt-joint with covering strips on each side of it, the clear space between each pair of rivet holes, should for any given diameter of rivets be twice as great as an "ordinary" joint made with rivets of the same dimensions. Judging, as we have said, from the proportions of the riveted joints of the kind we are considering, which have been actually adopted in practice, the fact just stated has been very generally overlooked, and the rivets have been set at the same pitch as if they were in "single shear" only. Under these circumstances the strength of the rivets is very greatly in excess of that of the length of plate left between the rivet holes, and the joint is, therefore, to some considerable extent, weaker than it would be if proper proportions were adopted.

The actual extent to which the strength of a butt-joint with covering strips on both sides is deteriorated by the adoption of a pitch of rivets, etc., suitable for "ordinary" joints, depends upon other considerations besides the one already mentioned, and how this is the case, we can perhaps best explain by an example. Let us, for instance, suppose a boiler, composed of $\frac{1}{2}$ in. plates, and having butt-joints with covering strips on each side, has been riveted up with $\frac{7}{8}$ in. rivets placed at 2 in. pitch—a proportion very commonly adopted in locomotive work—and let us see how far the strength of the joint can be increased by taking into consideration the fact that the rivets are in "double shear." In doing this we shall preserve the proportion between the areas of the rivets and of the plates between the holes unaltered—not that we consider it the best, however—and we shall suppose the strength of the joint to bear the same proportion to the strength of the solid plate as the length of the plate left between each pair of rivet holes does to the pitch between the centers of those holes. We are quite aware that this latter supposition is not exactly correct; but in comparing several joints with each other the error arising from the adoption of such a standard of comparison is very light. Having made these premises we may now return to our proposed investigation. In the case of the joints with $\frac{7}{8}$ in. rivets placed at 2 in. pitch, the length of plate left between each pair of rivet holes would be $1\frac{1}{8}$ in., or nine-sixteenths of the pitch, and the strength of the joint, measured according to our standard, would be nine-sixteenths, or $56\frac{1}{4}$ per cent. of that of the solid plate. Acting on the consideration that the rivets are in double shear, they might theoretically be moved to a distance of $3\frac{1}{8}$ in. apart from center to center, leaving a space of $2\frac{1}{4}$ in. between the holes, and increasing the strength of the joint, measured, as before, to eighteen-twenty-fifths, or 72 per cent. of the solid plate. If a pitch of $3\frac{1}{8}$ in. was admissible with rivets $\frac{7}{8}$ in. in diameter, we should, as will be seen, then obtain an increase in the strength of the joint equal to $15\frac{3}{4}$ per cent.; but practically it would be impossible to keep such a joint tight under high-pressure steam, and we therefore come to the conclusion that in place of increasing the pitch it will be advisable to reduce the size of the rivets in order to allow for the latter being in double shear. Let us, for instance, allow the distance between the rivet holes to remain $1\frac{1}{8}$ in.; and let us employ rivets $\frac{5}{8}$ in. in diameter in place of $\frac{7}{8}$ in., the area of the former being practically half that of the latter. Under these circumstances the pitch will be $1\frac{1}{8} + \frac{5}{8} = 1\frac{3}{4}$ in., and the length of the piece of plate left between each pair of rivet holes will be nine-fourteenths of the pitch, the strength

of the joint being thus, according to our standard, nine-fourteenths, or 64.285 per cent of that of the solid plate. The gain over the strength of the joint with $\frac{7}{8}$ in. rivets and 2 in. pitch, is not so great in this instance as when the space between the rivet holes was doubled; but it neverthless amounts to over 8 per cent—an increase well worth gaining.

We have, we think, said sufficient to explain the principles which we consider should be borne in mind in determining the proportions of riveting for butt-joints with double covering strips, and we need not, therefore, say more about these principles here; but before leaving the subject it may be interesting to point out a deduction to which the facts above stated lead. This deduction is that a properly proportioned single-riveted butt-joint, with any given thickness of plates, and with covering strips on each side, possesses nearly the same strength as a properly proportioned double-riveted lap-joint or butt-joint with a covering strip on one side only. In a properly proportioned double-riveted joint the spaces between the rivet holes (measured along each line of rivets, not zigzag) should be twice as great as that required in single riveted joints having rivets of the same diameter; and we have seen that the same rule applies to single-riveted butt-joints with double covering strips, hence our deduction. In a double-riveted butt-joint, with covering strips on both sides, the strength bears, of course, the same proportion to a single-riveted joint of a similar class that a double-riveted "ordinary" joint does to a single-riveted one.

In concluding this article we may notice one matter connected with riveted joints to which attention is not generally paid, and that is that the proportion which the strength of the joint bears to the solid plate increases with an increase in the diameter of the rivets used. The reason for this is self-evident. The area of rivet increases as the square of the diameter, whereas the length of plate (measured along the line of the joint) removed to make room for the rivet varies as the diameter of the latter only. Thus, supposing that with a certain thickness of plates $\frac{7}{8}$ in. rivets should be placed at a pitch of 2 in., leaving $1\frac{1}{8}$ in. between the holes, then, with the same thickness of plates, $1\frac{3}{4}$ in. rivets (supposing the use of such rivets was admissible) would have to be placed at a pitch of $6\frac{1}{4}$ in., the spaces left between the holes being $4\frac{1}{2}$ in. In the former case $43\frac{3}{4}$ per cent, and in the latter case but 28 per cent of the plates would be removed in forming the rivet holes. This fact shows that it is desirable to in all cases employ in riveted joints the largest diameter of rivets consistent with the fulfilment of other requirements, which practice has shown to be necessary for the attainment of good results.

UNDERGROUND RAILWAYS.

THE DIFFERENT SYSTEMS COMPARED.

The Metropolitan Underground Railway, in London, is the model, from which any departure would be, according to the majority of newspaper reports, presumptuous, unsafe, and not to be considered. We propose to review very briefly the various reports relative to this line, and the opinions of engineers upon it, with a view to give some light to those who take an interest in the subject as it affects New York and other American cities.

The accounts of the success of that work, published here, appear to have emanated from the promoters of various schemes of the kind for New York, and are more favorable than those we find in English engineering journals. For example: in a pamphlet on the Arcade Railway scheme is an extract from the "Evening Post," purporting to be from a report of an eminent American engineer, stating that the work is a great commercial success, and that, though it cost enormously, its dividends have been 12 and 15 per cent. But in the "Railway News" we find that the dividends have been 5 per cent for the first year, $5\frac{1}{2}$ per annum for the next half year, and 7 per cent from that time to the last half yearly dividend, which was at the rate of $5\frac{1}{2}$ per annum. And we find that there has been a serious controversy, in which the directors have been charged with impropriety in making dividends out of capital. A public accountant, Mr. J. P. Lithyre, in a pamphlet, says he was requested, professionally, to examine and report upon the affairs of the company, and that he found that the dividends had been paid mainly out of capital; and that the earnings had not been much over 2 per cent; and that, after closing the capital account, it would be a considerable time before the common stock would receive 3 per cent dividends.

We also see a report that another under-

ground line, in London, from the post-office under Holborn and Oxford street, is projected, to be worked by stationary engines. This indicates that the system of the Metropolitan line does not fully satisfy engineers. "Engineering," though it highly lauds the construction, rolling stock, and working of the Metropolitan, has speculated on improvements which would involve a general reconstruction, or something nearly equivalent.

And there are other systems, which for some years have been discussed, which imply that the Metropolitan is not the best system for city passenger traffic, however fit it may be for the work of the Great Western railway, for which it was built,—being an extension of that line into the heart of the city. Of these proposed systems, that of Mr. P. W. Barlow, has found most favor. Its main features are: 1st. Stations on summits, thirty feet or more above the general level of the line. 2d. Starting the trains from the stations, by very powerful stationary engines, at speed sufficient to send them to the next station. "Engineering" decidedly approves the summits, even for lines worked by locomotives.

Of the plans proposed here, which have been before the Legislature, the first conceived was that brought before the Legislature by Mr. Schuyler, two or three years ago. It was published in 1852, in "Appleton's Mechanics' Magazine," by W——n, (whom we take to be Mr. Worthen, C. E., then attached to the New Haven railway.) Its chief object was, to bring down to the lower part of the city the cars of the New Haven and other country lines; but it also had a secondary object, which was, the city passenger traffic. These objects are the same as those of the London line; and, had the plan been adopted here, probably it would have resulted, as there, in a success of the subordinate object, to such extent as to embarrass the chief object. This plan was, to run a double track railway, in an open cutting between Broadway and Mercer, and other streets in line. Since that time it has become much more difficult, on account of the buildings that have been put up on the rears of the lots; some of which have cost highly, and would greatly enhance the land damages.

Mr. Willson, at first, actively proposed the underground line in New York, after examining fully into the London line, and Mr. A. P. Robinson, C. E., who assisted him, were inclined to propose this route between streets, as much as possible, in open cuttings; but were constrained, by the prospect of enormous land damages, to propose a tunnel under Broadway. And the other underground plans, including the Arcade, have the same feature of being entirely covered, therein differing from the Metropolitan, which is one-third in open cuttings. Messrs. Willson and Robinson propose to ventilate through hollow lamp posts fourteen inches in diameter; and the Arcade is proposed to be ventilated trough the areas of the buildings. We do not believe that either plan of ventilation would render the air wholesome or endurable; and the ventilation through the areas would vitiate the air in the buildings, especially when the windows are open. Neither plan would work so well as that of the Metropolitan; and that excites much complaint, and though its friends are reticent about it in public, they privately admit that it is far from satisfactory. Mr. Johnson, its resident engineer, while in this city, said that the company intended to buy more land to make more openings; and Mr. Dredge, an engineer, who was employed in the construction, informed us that, twenty feet inside the tunnels, the sulphurous odor of the gases was perceptible. And there have been reports in the journals that the health of the employees has been seriously inpaired, and several passengers have died on the line. Compared with the open cutting plan, this plan is so inferior that no just amount of land damages can warrant its adoption, if we may judge from the evidence that has come under our notice; and the close tunnel and arcade plans, we believe, would be so much worse that locomotives could not be used in them without repelling the greater part of the people for whose use the work is proposed.

There have been other plans, but as they seem not likely to get moneyed backers, or to be further urged, we have no occasion to seek for their faults, and we know of no merits in them that require us to notice them particularly.

These tunnels would have a different character could they be worked by stationary engines, either on the rope-traction system, or on Barlow's system of impulsion. The rope system has not yet got beyond a very feeble infancy, totally inadequate to the service required in this city. That of Barlow has not been even tried, but it looks well in

theory. And, compared with the open cutting plan, for the line between Broadway and Mercer street, we think, in view of the land damages, that Barlow's system is not unlikely to be deemed best, after full consideration of the advantages and disadvantages of both plans.

Barlow represents—in papers read before the Society of Civil Engineers—that the cost of the permanent way will be much lessened if the 42-ton locomotives can be got rid of. It is commonly held that a 4-coupled locomotive of this class injures the track fully as much as twice its weight of carriages; and, as the trains weigh but 80 tons, it follows that more than half the cost of track is by the engines. And this wear is such, that the steel rails have to be renewed in two years. He also represents that the cost of stationary engines would be much less than that of locomotives. And fuel of ordinary quality could be used, instead of the best coke, at double the cost of coal. But the most striking advantage claimed is a considerably higher speed; the stationary engine, drawing by means of a chain, is not limited in power like the locomotive, by liability to slip, but may draw with a force equal to the weight of the train, or greater; whereas, the Metropolitan engines draw with a force not exceeding $\frac{1}{3\frac{1}{5}}$th of the weight of the train and engine. Therefore, in a thirty-fifth of the distance between stations, the stationary engine *may* do as much work as the locomotive can do in the whole distance. And practically, there is no doubt, a stationary engine, working with a chain over two pulleys two hundred feet apart, may start a car or a train with sufficient speed to overcome all the resistances on a line of half a mile, and arrive at the next station at a useful speed of six miles an hour or more. The descent from the summit will help to give the speed; and the ascent to the next summit will help to extinguish it, or will reduce it to a low rate, which the brakes will extinguish without much wear of wheels.

To explain this, let us suppose an excessive undulation of the line. Let the stations be on a level with the sidewalks, so that the passengers need not have the fatigue of going down and up stairs, for twenty feet average as proposed by the tunnel projectors, or seventeen feet as proposed by the arcade people. From these stations let the line descend both ways, at the rate of 1 in 5, for 660 feet. In running down this incline, a car will acquire a speed of 60 miles an hour; it will not only overcome the inertia of its weight, but will also overcome the additional inertia of its wheels and axles as rotating bodies. It will then continue to run, on a level, at 60 miles an hour, until it reaches the next incline, which it will ascend, and arrive at the summit with its speed extinguished. In this case we suppose that it has had no friction or atmospheric resistance, or that these resistances have been overcome by additional power given by the stationary engine. Thus the power required to start is given by gravitation, and taken back by gravitation; and only the power necessary to overcome the resistances of steady running has to be given by the fuel, with a small addition for an excess of speed of six miles an hour, at the end of each run, to save time.

In this mere illustration we have supposed an inclined plane from the summit, and a level to the next incline; but Mr. Barlow proposes a cycloidal curve from summit to summit, as the line of quickest transit.

In the descent, on the inclined plane, the car would run an eighth of a mile at an average speed of thirty miles an hour, and would then run a quarter of a mile at the rate of sixty miles an hour, and then ascend the next incline at an average of thirty miles an hour, making three-quarters of a minute for the half mile. It would then stop three-quarters of a minute—which is the time on the Metropolitan—making one and a half minutes, or three minutes per mile, or an average speed of twenty miles an hour, with stations one-half mile apart. Now "Engineering" computes that $13\frac{3}{4}$ miles an hour is the highest speed practicable on the Metropolitan system, with stations five-eighths of a mile apart. Thus it seems that, without exceeding the maximum speed obtained on English railways—64 to 75 miles an hour—we can get an average speed one-half greater by Barlow's system than we can get by the Metropolitan system, or the modifications of it proposed here.

Comparing the plan of Mr. Schuyler or Mr. Worthen with the tunnel or arcade, we find certain advantages in each. As to speed, it will be greatest where steam can be made most freely, that is, in the cuttings. In the tunnels, on the Metropolitan, the exhaust is turned into a condenser; and not more than one-eighth as much steam is made as is made in the cuttings, where the blast is used. And here, we are confident, the covered ways will prohibit rapid steaming;

and high speed will be attained only in the open cuttings. On the other hand, the covered line will be protected from atmospheric influences, which will render a better construction practicable, and insure greater durability, and get rid of the troubles due to snow and ice, and the cost of removing them. This advantage will be most fully attained in Barlow's plan; for that admits of being entirely housed, covered, and ventilated by the best methods; so that the temperature need not vary beyond the limits of 60° in winter, and 80° in summer. The permanent way may, therefore, be uncommonly permanent; but whether the air will be pure enough for health and comfort is a more doubtful question, which may be answered, more or less confidently, by those who are accustomed to ferry boats, city cars, and other conveyances controlled by men who have got their franchises by favor or otherwise, and use them solely to gain all they can by them. In view of such uncertainties, the open cutting will have numerous advocates.

A station on the Barlow plan will occupy the lower story of nearly the whole rear of a block, for a width of 30 feet; but it may be built over, to any height, by those who supply dark offices to people who are so improvident as to use them. From this block the line will descend so rapidly as to go under other blocks, without disturbing them—the tunnels being driven. The land damages will therefore not much exceed the cost of land for the stations.

The cutting plan will occupy at least 28 feet wide through the back yards. This, or even 40 feet, would really be no loss to the property, for the light-room would be worth more than the buildings that could be put upon it; but this is not the opinion of land owners, and they would demand, and probably get, immense damages—perhaps so much as to render the work unproductive

There is another plan proposed in a paper on underground railways, read before the Polytechnic Club of the American Institute, by Mr. J. K. Fisher. He proposes to adopt the open cutting plan, locating it where land damages may be less than on the line between Broadway and Mercer street; and to modify it by laying an iron floor instead of rails, and by running steam carriages instead of trains drawn by locomotives. He claims that the carriages can pass each other, so that through carriages can run from end to end without stopping, at full speed; and that the speed may be greater than is attainable on rails, because the flange and cone friction will be avoided. For an up-and-down line 40 feet width would be required; and a guard in the middle, to keep down-carriages from meeting up-carriages, might be adopted; so that collisions could occur only by carriages overtaking others, and the violence would be in proportion to the difference of their speed, and not so great as to cause injury to persons. But when two streets of this kind are built, one may be used for upward, and the other for downward carriages, and the guard may be removed. No pedestrians, and no vehicles but those of the company, to be allowed in these undergrade streets; and all vehicles to run at one rate of speed when on the middle of the street; and to turn out before they stop. The stations may be nearer together than on a railway; and the way-carriages may pass some of them, so as to make fewer stops than trains must make; for example: Carriage A, starting from station 1, may stop at station 3, 5, 7, etc., or at 4, 7, 10, etc.; and carriage B may stop at intermediate stations, so that passengers will be better accommodated, and the speed will be less interrupted than on rails, where every passenger must stop at every station.

Steam carriages are under a cloud, which their friends regard as a cloud of ignorance. They were designed for common roads, and ran upon them to the extent of 50,000 miles or more, before railways got much into use. They were practically approved by several of the best mechanical engineers in the world, who took out patents for improvements in them, and built them. Among these engineers were Maudsley, Field, and Richard Roberts, then at the head of their profession; and Scott Russell and W. A. Summers, then rising to celebrity. But the iron road beat the macadam road; and the locomotive, then called a steam carriage, was supposed to have beaten a lighter steam carriage; but there was powerful opposition to both systems of steam locomotion, against which the common road carriages did not prevail. But about twenty years ago Mr. Brydges Adams proposed steam carriages for railways, and built several, which worked well where the traffic was insufficient for trains. In this country we call them steam cars, and have used them, and still use them, to a considerable extent; and Mr. A. P. Robinson, in his report of a plan for a tunnel railway under Broadway, proposes to

adopt them exclusively for that line; and gives engravings of two plans, one by Grice and Long, the other by Mr. Fisher. Take the flanges from their wheels, and add steering gear, and these cars become steam carriages capable of running on any good road. It is supposed that they cannot run profitably on a poor road; but none who have examined them doubt that on iron or even stone floors they can work advantageously.

The question, therefore, is: can light engines, on equally good roads, with stations half a mile apart, work more economically than heavy engines? Can 125 tons be stopped and started as cheaply as ten tons, or less? Mr. Robert Fairlie, C. E., distinguished as the inventor of a new locomotive that is coming much into use, has shown, in a paper read before the Society of Engineers, that the average number of passengers, per train, on the Metropolitan railway is 55. A 10-ton carriage could carry them; and most of the work done in the middle of the day could be done by a few light carriages, leaving the greater number at rest until the movement of people to and from their business. Not only is an unnecessary weight of train used for a small traffic during a great part of the day; but this weight stops and starts at all stations, and cannot do otherwise on this system. Now, on several of our railways, whose maximum speed is not much greater than that on the Metropolitan, careful observations have been made, to find the cost of stopping and starting trains; and they agree, very nearly, that one cent per ton is about the cost. Mr. A. F. Smith, ten years ago, when superintendent of the Hudson River railway, estimated that it cost $1.25 to stop and start a passenger train on that line, on which the trains averaged about 125 tons. Now there is an advantage in favor of a steam carriage, in that it can stop by reversing, and thus avoid wear of its wheels by brakes; and this advantage, where stops are frequent, goes far to balance the greater economy of large engines, so that it is not extravagant to say that one cent per ton would pay for stopping and starting it, and that this considerable part of the working expenses will be lessened in proportion as the weight to be stopped is lessened. But as the through carriages will make but few stops, and the way carriages will stop less than the trains, there will be further reduction on this score. Moreover, if a single carriage breaks down, it will slide along on a floor, and no person will be hurt; but if a locomotive, or a car in a train, break down, all that follows will dash against it, and many may be killed and wounded. Therefore it is necessary to make the railway vehicles excessively strong and heavy for safety. The cars on the Metropolitan weigh sixteen tons empty. Half this weight could be saved were they not subject to be strained by the 42-ton engines, and were there no serious harm to come in case of breaking down.

Considering all these conditions, it is probable that eight times more fuel is consumed on the Metropolitan railway, for an equal number of passengers carried, than would be consumed on an iron floor by steam carriages; and that this consumption of fuel is an approximate index of the wear and tear of engines and carriages.

All these schemes should be tested, so far as practicable, before risking a vast capital upon any of them. The cost of testing the economy of either of the railway plans would be great,—miles must be built and worked for some time before a reliable judgment could be formed. But to test the unsettled questions relative to steam carriages, whether they can be steered securely at the speeds desired, and can work effectively and economically, would involve little cost, for one may be tried on any good macadam road. A very large boiler would be required to test the practicability of steering and handling, at high speed, on a common road; but this would be allowed for in estimating the useful load that may be carried on an iron floor.

In this plan the way traffic will not retard the through traffic, nor the intermediate traffic, but each carriage will run at as high a speed as if it had the whole road to itself. A carriage that loads at the Battery and unloads at Harlem, will run through at full speed; and one that stops at two or three stations below Canal street, to pick up passengers, will run eight miles at full speed, and then stop at two or three stations to set them down and pick up others. And the short traffic, by alternate carriages stopping, will be made somewhat speedier than it can be on rails.

The tractive force of the locomotive is relatively small—30 tons on the drivers to 125 tons total weight; but the steam carriages will have twelve tons on the drivers to 20 tons total weight; its power to start quickly will, therefore, be greater in the

proportion of two and a-half to one; and this would enable it to attain a considerably higher average speed on the short traffic. It is understood that on long runs the speed is due to the boiler; but on short runs it is due, in a great measure, to the cylinders, since they get up the speed. Mr. Fisher claims that sixteen miles an hour may be got on the short traffic, and 40 on the through traffic, and intermediate rates on the intermediate traffic, according to the frequency of stops; and these rates will not tax the engines or the way more than they are taxed in English foot passenger practice, or on the Metropolitan railway.

Having thus compared the Barlow tunnel plan with the open cutting plan, worked in two different ways, and shown that the speeds probably will be, for the railway in the cutting, thirteen and three-quarters at the utmost, and for the floor, sixteen to 40, and in the Barlow tunnel it may be 20; we may briefly consider the speed of the rope-traction tunnel plan which Mr. Hawkshaw proposes to go under Holborn and Oxford street. The wire rope is to run all the time at sixteen miles an hour, and the cars are to have means of "slipping the rope," which, we presume, means that they are to catch hold of it in such wise that there will be some kind of yielding, that the car may start gradually. Mr. Harvey, on the Greenwich street elevated railway, has springs on his cars, which are bent by the rope to soften the shock, and to avoid loss of power by friction. But this plan does not work well even at eight miles an hour; and the rope system on the Blackwall railway did not do what is required for the lines now proposed; and we know nothing of Mr. Hawkshaw's new devices, if he has any; and though we don't venture to say what can't be done, we say that the rope system has had a long trial, under the Stephensons, and failed to equal the locomotive; and it must be farther improved before it will equal the plans we have herein set forth at some length, but not fully. But we will suppose, for the comparison, that Mr. Hawkshaw has devised means to take hold of the running rope without wearing it, and to start his car gently, and to do all he requires in this detail. What, then, is to be his speed? It will be liberal to take only one mile from his sixteen for the half speed, while the cars are stopping and starting every half mile. It will require, then, two minutes to run half a mile, and three-quarters of a minute stopping, which is five and one-half minutes per mile, or less than eleven miles per hour average speed. This is about what "Engineering" estimates for a line like the Metropolitan, if its stations were only half a mile apart; and we suspect that Mr. Hawkshaw has aimed merely to equal the speed of that system, and that he has found no encouragement to aim at more.

Which system, then, is wanted? Speed, we presume, is the chief object in the estimation of the customers, who are ultimately to pay for the work. Fresh air is also growing into favor, to such an extent as to mitigate the objection that it would cost considerably to keep the open way free from snow and ice. These two requisites, speed and air, will be most surely found in the cutting. But they must be paid for in land damages, etc. The other plan, that of Barlow, is very comfortable in theory; but in practice we should expect more or less foul air, not to mention want of daylight. And the average speed may be set down at a third less than that on the iron floor. But Mr. Barlow estimates that the running expenses will be small compared with locomotive expenses. Into these estimates we are not prepared to go, and we find no careful estimates in our cotemporary journals.

Having given the gist of all we find worth reporting in the journals and other records, we might stop; but there is a modifying power which often overrules the opinions and even the experience of engineers, and which is very likely to derange such matters in this city. Lobbiers go to the Legislature and buy franchises to sell. These lobbiers know nothing of engineering; they take what has been successful elsewhere; they exaggerate its success; they get up companies; they bull their stock and water it, and sell it; their job is then completed. And it is good luck if the plan they have established is not a bad one, made worse by being put in a place for which it was not designed. It may have on it the names of engineers; but engineers, like lawyers and other advocates, look out for fees. As one has little faith in a lawyer whom he does not pay himself, so he may about as well look out for engineers whom he does not pay. Not that engineers are less honest than other professional men; but, like others, they are of all sorts; some will resign their employments rather than betray stockholders, or swindle the public; others will hesitate, etc. But any set of lobbiers

can get engineers enough to engineer any plan that is already "a success," though there may be better plans, which, whenever set to work, will underwork and render profitless the plans which are thus far successful, only because they have only old and worse plans to compete with. And we suggest to city men, who want these improvements, and intend to take and hold stock in them, that they would do well to employ engineers, on their own account, to get up plans, rather than buy the franchises which lobbiers have got from the Legislature.

In conclusion, we judge from the somewhat vague evidence, that the success of the Metropolitan railway has been greatly exaggerated; that the plan is deemed defective by many, if not most engineers; that it was not planned for the use into which it has unexpectedly fallen; that there are better plans for city traffic; and that it is not at all fit to go under streets where there cannot be openings enough to allow the steam blast, at regular intervals, for at least a third of the way. And, finally, that it cannot be applied in this city so usefully as either of the other plans which we have reported.

In these comparisons we have supposed the highest speeds that can be attained as about equal to what is practiced on the Metropolitan railway. It may be thought that the speeds should be less, so that the expenses and fares may be less. But the time of 55 passengers, for the 4.8 minutes required to go a mile, is worth $2. 64, at one cent per minute per person, which is a low average for business men. And this high cost of time ought to be lessened. But those who do not appreciate this economy may assume any lower rate of speed, attended by less wear and tear, and by lower fares. And the saving will be as great in one system as in another, so far as we can now judge; and the comparison which we have made for high speed will hold good for any lower rate that may be acceptable to passengers, and profitable to the carrier.

A Gunpowder Pile-driver was described at a late meeting of the Franklin Institute. It resembles the ordinary pile-driver, except that a charge of powder is exploded, whereby the weight is forced up, where it is caught, till another charge is inserted. A 400-pound hammer can be operated with musket charges, driving the piles quicker and better than the ordinary pile-driver.

IRON ARCHED BRIDGES.

From a paper before the Société des Ingénieurs Civils, by M. Yvon-Villarceau, on the application of his theory of arches to the building of iron bridges.

For several years cast iron has successfully taken the place of wrought iron in iron bridges, with the exception of tubular and suspension bridges. The difference in the cost of wrought and cast iron is not the only reason of this change. In fact, if cast iron offers as much resistance as wrought to compression, it is quite different as regards tension, and it is known that engineers reckon little on the resistance of cast iron when undergoing strains of this nature; they then prefer to use wrought iron, which allows them to obtain much smaller sections than they could if they employed cast iron. The possibility will thus be perceived, in employing wrought iron, of reducing the building expenses of iron bridges where the metal offers resistance to tensile strains. But in supposing it possible to obtain, in this manner, a certain economy, there would be, by that very fact, a reduction in the mass of the construction: a consequence of this reduction of the mass is a diminution in the stability, because it is highly important that the bulk of vehicles and casual weights be as small as possible in relation to that of the construction itself. Finally, the theory of iron bridges, where, at certain points, the metal offers resistance to tension, and at others to compression, is not yet established, and engineers, obliged to have recourse to experience, prudently avoid extending the results to buildings of different dimensions from those they have already tested.

Cast iron bridges do not offer the same drawbacks. They may be so arranged that the metal will only have to resist compression, and the low price of the metal allows a lesser economy of the bulk employed. These motives seem to sufficiently explain the preference given at the present day to the use of cast iron in the building of bridges.

Let us now attempt to show how our theory of arches may be applied to the building of cast iron bridges. An arch of a cast iron bridge comprises three distinct parts. Firstly, the roadway and superstructure; secondly, the cast iron framing comprised between the floor and the extrados, and equivalent to the stone work of stone bridges; and, thirdly, the arch or assem-

blage of framing, analogous to the voussoirs of stone bridges, and which will fill the place of these latter. It will be first remarked that the framing of the system equivalent to the stone work is in the shape of hollow prisms with a vertical axis, ended at the upper part by an horizontal plane, and at the lower part by a curved surface in contact with the extrados of the arch. This arrangement of prisms agrees the more exactly with what we considered in our paper on the building of arches of bridges when their parts parallel to the road are more limited. The objections raised by some persons against the theory of normal action at the extrados in stone bridges could not be applied in this case, so that that theory may be said to apply more exactly to cast iron than to stone bridges.

The transition of the theory of stone bridges to cast iron bridges may be made in the following manner. Let us consider one of the vertical prisms forming the bulk of the bridge, and let us compare its weight with the weight of this prism. When considered as solid, we will deduce therefore the weight of the unity of volume, or the density of this prism. The first condition to be fulfilled is the coincidence of the actual center of gravity of the prism, and of that of the prism when solid; the second is that all the prisms have the same density in the whole of the construction.

These two conditions are easily filled; it would suffice to obtain the figure of the resulting internal space. Let us pass on to the framing constituting the voussoirs; their density would be obtained in the same manner as for the other prisms, and we will obtain at once the same conditions as regards the equality of density and the position of the center of gravity. If the theoretical conditions are to be rigorously carried out, there would remain to reduce on the intrados, the surface of contact of the voussoirs on the small space which separates the actual and imaginary intrados.*

There remains to be examined the question of pressure. In the whole extent of the structure, considered as filled, the pressures are equal to those produced by a liquid, the density of which would be equal to that of the structure, and the upper surface of which would be loaded with a weight equal to that of the roadway and superstructure; consequently, the pressures transmitted by the structure on the vertical sides which form its boundaries act horizontally, and the pressures received by the extrados are normal at its surface. To pass from these pressures, estimated on the hypothesis of continuous surfaces, such as those of the prisms or stone voussoirs, to those which answer to the case of prisms or hollow cast iron voussoirs, it evidently suffices to multiply the first by the relation of the surfaces which are in contact with the filled (solid) system with the corresponding surfaces of the hollow system.

It is evident that in the cast iron prisms or voussoirs the only surfaces of contact to be taken into consideration, are those capable of effectually transmitting pressures. (For instance, no notice ought to be taken of the surfaces of the cross bars used solely for forming connections in the direction of the axis of the arch.) The pressures thus obtained ought not to exceed a previously determined limit. Let us add that it would be always possible to render the pressures constant on each unit of surface—the whole extent of the arch, because, within large limits, the surfaces of contact are to be disposed of.

In stone bridges subjected to the conditions of stability we have laid down, if we have given us the opening of the arches, and the ordinates of the summit of the intrados, and of the springing lines in relation

* The theoretical conditions might be realized without touching the joints, by giving to the arch a constant thickness, e, which would render the extrados and intrados perfectly parallel to each other. For this purpose let $\tilde{\omega}$ be the weight of the unity of volume of the voussoirs, as previously defined, and $\tilde{\omega}'$ a variable density, according to the formula

$$\tilde{\omega}' = \tilde{\omega}\left(1 + \frac{1}{6}\frac{e}{\rho}\right),$$

in which ρ represents the radius of the curve; the space of the voussoirs would be got rid of to realize the density $\tilde{\omega}'$ relatively to each by fixing the center of gravity at the point determined by theory, and the pressures could nevertheless be calculated in retaining in the general formulæ the quantity $\tilde{\omega}$.

In this case the actual intrados would be confounded with the imaginary one, of which it would suffice to consider the co-ordinates.

Preference, it appears, ought, however, not to be given to this solution; it is better, in fact, not to extend the contact of bodies undergoing considerable pressures to the extreme limits of the flat surfaces of contact. On the other hand, we are accustomed to see the thickness of arches increase towards the springing line, and the effect upon the eye is generally pleasing.

to the horizontal plane which forms the limit of the surcharge, it will be found that the section of the intrados is nearly determined, independently of the thickness of the keystone, and the result is all the more exact when the densities of the materials of the surcharge and of the arch are the nearer equal. The whole bulk of the structure being then sensibly constant, the stability increases more rapidly than in proportion to the thickness of the arch, because it would be in proportion to this thickness if the mean pressure per unity of surface were constant, and this mean pressure decreases in inverse ratio to the thickness of the arch. As regards stability, it would therefore be better to increase the thickness of the keystone until there would be above it but the strictly necessary thickness of overcharge. This is not always done, and the reason is evident, because the price of a cubic meter of stone, cut and dressed as voussoirs, exceeds to an enormous extent that of filling up materials. In cast iron bridges, where a similar disproportion does not exist, there is nothing to prevent the arch from having the complete thickness demanded by a design. In the previous reasoning it is supposed that the casual overcharges result usually in increasing the pressures in the joints, so that it is to the interest of the engineer to diminish those which show themselves in the absence of any overcharge. When we consider the chances of decrease in the pressures, such as those which would result from slight motion of the soil, or sinking of the piles, one is lead to avoid reducing too low the pressures corresponding to the normal state of the arch. But if it be remarked that the casual surcharges are for cast iron bridges in a greater relation with the bulk of the structure than for stone bridges, this circumstance would be a motive for reducing the normal charges of cast iron bridges. Besides the connections made between the framework by bolts, present, to ward off cases when the casual pressures would fall a few points below zero, advantages incommensurably superior to those that could be expected from the cohesion of the mortar in stone work.

Let us finally add that if, without increase of expenses, it can be so arranged that the densities of the structure and voussoirs, understood as we have before said, be equal, the calculations to be done will be sensibly abridged, either directly or by means of special tables.

A New Steel-Headed Rail. — The "Engineer," after pointing out the various defects of welding steel slabs upon rail piles, expresses great confidence in the new (?) process of Mr. E. Gray, of Sheffield, which it describes and illustrates at length. The process is simply *casting* a steel slab upon an iron pile. The iron pile is heated and set in an ingot mould, but it does not fill the ingot mould; a space, say one to two inches wide, is left at one side, into which liquid steel is poured. The steel is expected to unite perfectly with the iron. The whole is then rolled into a rail, the steel surface forming the head.

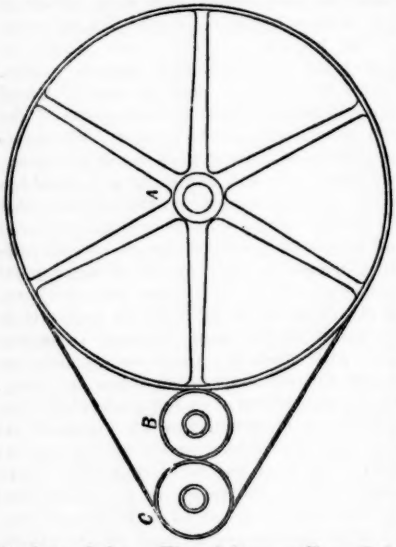
We do not think this process, as described, can be relied upon, but that some radically new means and apparatus must be developed for overcoming the many practical difficulties. Our reason for thinking so is, that we have tried this plan without constant success—indeed with very uncertain and variable results. We have heated and set up in ingot moulds, iron slabs and blooms for rails, and iron cores for axles. Liquid steel poured into the mould would fuse and soundly weld to such parts of the iron as were *clean* and very hot. The practical difficulty is in getting out of a furnace, and setting up and centering in a mould, a heavy mass of iron, with such celerity that the surface shall not become much cooled and oxydised. Another more serious difficulty occurs in the case of casting a mere surface of steel upon an iron pile or bloom. If the iron bloom is made to perfectly fit the mould on the three sides not to be covered with steel, it cannot be got into the mould hot—the operation takes too long. If the iron bloom does not perfectly fit the mould, the steel will run all around it in thin fins, which have not mass enough to hold their heat and weld uniformly. The three sides of the resulting ingot, intended to have iron surfaces, have, in fact, facings of steel, partly welded and partly chilled upon the iron. When such an ingot is rolled it is sure to crack in the flanges, and to make a rough, bad rail.

We have also made several hundred rails by setting up heated iron or steel rail ends in the center of a mould, and casting steel around them. The mass of liquid steel being so thick, and the mass of the core being so small, a good weld generally resulted, but *not always*, and this uncertainty led to the abandonment of the process.

The theory of welding steel to iron is ex-

cellent, and the practice is very satisfactory when the conditions are properly provided for. We have seen absolutely perfect welds made in this way—welds in which no test could discover the slightest want of continuity of the mass. But the present practical difficulties must be overcome. The plan shown in the "Engineer" is not trustworthy; nor is it new. Dr. Percy describes the same thing as proposed for the manufacture of tyres. And we have heard that it was proposed in this country at a much earlier date than our use of it. Here is a fine field for experiment, and we hope that this grand principle will be successfully worked out.

PULLEYS FOR SHORT BELTS.—Messrs. Gwynne, centrifugal pump makers, of London, use the arrangement shown in the cut, for saving space and strain in the use



of short belts. The driven pulley *C* is placed close to the driver *A*, so that the belt touches but a small portion of its circumference. The belt, therefore, has to be very tight; and to relieve the journals from the great pressure and wear thus imposed, the pulley *B* is placed intermediate between the others. This intermediate pulley is recessed in the center of its face, so as to bear on the others at the edges only. The arrangement is said to work well, and is more fully illustrated in "Engineering" of January 22.

LARGE HYDRAULIC TESTING MACHINE. —Messrs. Paulding, Kemble & Co., West Point Foundry, are making for L. B. Boomer, Esq., the eminent bridge builder, a machine for testing full-sized parts of bridges—rods, castings, etc.—up to 40 feet length and 400 tons pressure, either thrust or pull. The cylinder is 17½ in. diameter, and nine inches thick; the stroke eight in. The ram is single acting, being brought back by a rack and pinion. The cylinder is hung on trunnions—in fact it would be taken by an artilleryman for a 17½ in. mortar. When pointed in the direction of the 40 ft. bed-plate, it pushes directly upon or compresses the piece to be tested. To bring a tensile pull on the piece, the cylinder is turned away from it, and the power is brought to bear on it by means of a cross head, cross tail, or head block, and two side rods. The side rods are forged from Bessemer steel, and are four inches square. The cost of the machine will be about $5,000. Such a machine, for testing full-sized parts, has long been wanted in this country. The tests of little, short specimens, turned down to a mere wire in the middle, are not accurate, and the changes of figure are not easily measured.

STEAM CULTIVATION.—The success of steam cultivation was long ago established, and to say that steam is cheaper and better than horses in the field is as trite as to say the same of it on the railway. It is no longer a question of steam *v.* horses, but of the newest *v.* the earlier forms of steam tackle. More powerful engines, of much better construction, and worked at higher speeds are now in use, and some of them, working up to 100 indicated horse power, are hauling six and even eight-furrow ploughs in moderately stiff land, or dragging cultivators from 12 ft. to 15 ft. wide, and that at a rate of four miles an hour. The money saving had been proved by many cost sheets, and as for the work itself, it could be done in all weathers, done upon land which horses could not touch, or where they could not stand, done at a faster pace, the pulverization of the soil being as the square of the speed at which it is knocked to pieces; and then there was not a single one of the hoof-tracks, where horses' feet, like pavior's mauls, ram the ploughed earth into a hard pan like a pavement—hoof tracks, of which, with a full team in heavy ploughing, there may be as many as 300,000 to the acre.

THE SUEZ CANAL.

AUTHENTIC ACCOUNT OF THE WORKS, MAINTENANCE, DIFFICULTIES, WORKING, ETC.

Compiled from a letter by Mr. John Fowler to the London "Times."

PORT SAÏD HARBOR.—A harbor for the entrance to the canal has been constructed at Port Saïd by running out into the sea two breakwaters formed by artificial blocks of stone. These are composed of one part of hydraulic lime from France, and two parts of sand obtained on the spot, and are therefore really hard mortar. The harbor is intended to answer the double object of protecting vessels from heavy seas and of arresting the alluvium brought down by the river Nile, so as to prevent its choking up the channel. The western breakwater extends from the shore 2,400 yards in a straight line towards the north, and then with a slight angle towards the east extends 330 yards further. The eastern breakwater leaves the shore at the distance of 1,530 yards of the commencement of the western breakwater, and extends nearly north for a distance of 2,070 yards, at which point it is 760 yards from the western breakwater, and this distance constitutes the width of the entrance. The portion of the harbor affording shelter to vessels is nearly 500 acres in extent, and, although the depth of water is not sufficient for the largest men-of-war, it is quite sufficient for ordinary merchantmen, if the present depth be maintained.

Large quantities of alluvium are constantly brought along the shore from the Nile, and since the construction of the western breakwater this deposit has changed the line of the shore, while large quantities have found their way through the interstices of the artificial blocks of which the breakwater is composed, into the harbor, and are forming deposits there; it will be found necessary to make this breakwater solid. It is possible this outside accretion may require at some future time a prolongation of the breakwater, and it may be that northerly winds will occasionally bring sand into the harbor; but I do not consider such contingencies to constitute any real objection to the design, or likely to be formidable in expenditure, considering the gigantic character and objects of the whole undertaking.

DIVISIONS AND SECTIONS OF THE CANAL.—The canal may be conveniently divided into the following portions:

	Miles.
1. Port Saïd through Lakes Menzelah and Balla to near El Ferdam	37
2. From near El Ferdam through the great excavation of Seuil d'el Guise to Lake Timsah	9¼
3. Through Lake Timsah	5¼
4. From Lake Timsah through the excavation of Seuil du Sérapéum to the Bitter Lakes	7¼
5. Through the Bitter Lakes	23¼
6. Through the deep portion of Chalouf Cutting	5
7. Thence to Suez and the end of the canal.	11
Total	99

With minute exceptions the whole of the canal is now being excavated and completed according to one or other of the following sections:

1st. 196 ft. in width at the surface of the water, and 26 ft. deep for 72 ft. at the bottom. The slopes are two horizontal to one vertical, with one or more horizontal benches of 10 ft. in width, according to the depth of the cutting.

2d. 327 ft. in width at the surface of the water, and a similar depth of 26 ft. for a similar width of 72 ft. at the bottom. The lower part of the excavation is also two horizontal to one vertical, but the slopes above and below the surface of the water are five to one, and a horizontal bench of 58 ft. connects the two slopes.

It will be observed in the description of the second section that the slope at the surface of the water is flat (five to one), and provision is now being made for protecting this slope with rough stone pitching, trimming the upper slopes, and otherwise treating it as a finished work. This may be safely done, because the section is so arranged that the canal may be widened at any subsequent period without disturbing any of the work already done. With the first section, however, the case is different. This section has been adopted in the deep cuttings to effect the largest saving possible in the quantity of excavation, and, therefore, if a future widening of the canal is required, one or both side slopes must be thrown back, and a considerable portion of the present work interfered with. As a rule, no stone pitching or other protection against the wash of passing vassels, or wind, or current, has been provided for the part of the canal where this section has been adopted, although the slope at the surface of the water is two to one.

At each end of the Bitter Lakes careful provision is now being made by temporary

weirs and sluices at the sides of the canal for the admission of water into the lakes from the Mediterranean and Red Seas. This provision has been calculated with reference to the time and quantity of water, and a sufficient margin appears to have been given for possible contingencies.

THE WORKS AT SUEZ.—These consist chiefly of an entrance channel into the Red Sea, increasing gradually from 72 ft. in width at the bottom to 980 ft. of a basin or dock, and a considerable extent of reclaimed land.

WORK DONE AND TO BE DONE.—The total quantity of work in cubic meters of excavation originally required for constructing the canal according to its present dimensions and design was as follows:

	Cubic meters.
Total work	78,000,000
Work executed up to Dec. 15, 1868	53,000,000
Leaving still to be executed	25,000,000

The number of men, animals and materials which were on the ground and available for the work on the 15th of December, 1868, was as follows:

Workmen	8,213
Camels	368
Donkeys	116
Dredging machines	60
Inclined planes of railways	22

The quantity of work yet remaining is very large, but taking the progress made during the last few months, and applying the same rate for the future, it appears to be possible that in the absence of some unforeseen contingency the canal may be sufficiently completed for the purposes of traffic during the present year.

MAINTENANCE OF THE CANAL.—The question of maintaining the canal and its harbor of Port Said permanently open for traffic has excited almost as much professional and public attention as the construction itself, and in some minds probably much greater doubt and difficulty have been felt on this than on any other point.

The difficulties of maintenance may be divided as follows:

1. *The Prevention of Nile deposit from choking up Port Said.*

The remedy for the mischief, which may be said to have commenced and to be now continuing (and to which we have referred above), is either to admit the sand to pass through the breakwater and then depend upon dredging, or to make the breakwater solid, and encounter the difficulty, whatever it may be, of its greater accumulation outside. The rate of accumulation in the angle formed by the western breakwater was naturally very rapid in the commencement, because the area was small, and the water was impounded in such a position as to be almost without motion; but as the new shore formed by the deposit advances seaward this rate of advance is rapidly and constantly decreasing. The time has not been sufficient to collect adequate observations by which any law or formula could be founded to represent the future rate of the advance, but it is, however, very clear that many years must elapse before the line of shore can possibly reach down to the angle of the breakwater, and it may be that at or near this point the accretion seaward will cease altogether; but the greater probability is that, although it may have become small, it is still going on, and the necessity of extending the western breakwater, at some future time, further into the sea, is likely to be required. No apprehension need be entertained as to the channel and harbor being silted up and destroyed, but at the same time considerable expense in dredging will be constantly required.

2. *The Impossibility of Preventing the Sand of the Desert Blowing into the Canal in Quantities totally Unmanageable.*

This objection has been felt to be one of great weight, and when it was considered generally and without the correction of local knowledge it appeared to be fatal, because if the whole or nearly the whole distance from sea to sea had been through a desert composed of fine drifting sand it would have been hopeless to maintain the canal open; but, fortunately, the only portions of the canal which will be liable to be affected by the sand of the desert to any extent worthy of consideration are the two excavations on each side of Lake Timsah—viz: Seuil de Guise on the north, and Seuil du Sérapéum on the south. Fortunately, a tolerably satisfactory means of ascertaining the annual amount of drifting sand has been afforded by an investigation lately made during a period of twelve months, and the result is that 40,000 cubic yards was found to have passed into Seuil de Guise, and 270,000 cubic yards into Seuil du Sérapéum. These quantities, no doubt, are very large, and it is quite possible that during some years they might be exceeded, but the company are making provision to diminish the quantity by trying ex-

periments with trees and shrubs, so as to plant the slopes and the ground for some distance on each side of the canal. It is also probable that water from the fresh-water canal will be made available for forming an extended oasis at and around this portion of the canal. These operations will be somewhat expensive, although they are doubtless prudent and desirable, but after every precaution has been taken it will be necessary to keep one or two powerful dredges in Lake Timsah to keep the canal clear from drifting sand.

3. *The Difficulty of Protecting the Banks against the Destructive action of the Wave caused by passing Vessels.*

It will be found necessary to make a proper and immediate protection of the slopes by stone pitching above and below the surface of the water along the whole course of the canal if the traffic is to be conducted at a reasonable rate of speed; the engineers of the Canal Company have arrived at the same opinion. This work will no doubt be executed much more conveniently and economically after the canal is opened throughout, and the large quantity of stone required can be conveyed without charge; but, on the other hand, it will be more difficult to place the stones below the level of the water, and probably the slopes may have sustained some mischief before the work can be done.

4. *The Impossibility or Difficulty of Supplying the Abstraction of the waters of the Bitter Lakes during the Evaporation of the Summer Months through the Ordinary Section of the Canal between the Bitter Lakes and Suez.*

The vast extent of the Bitter Lakes (100,000 acres in superficial area) when connected with the tidal Red Sea by the Chalouf excavation, will produce in the summer months, when the evaporation is greatest, peculiar currents and hydraulic phenomena. The largest daily evaporation or abstraction will amount to about 250,000,000 cubic feet of water, and this will be chiefly supplied from the Red Sea, which is far nearer than the Mediterranean, and has a tidal range of about 6 ft. in spring tides, and 2 ft. at neap tides, while the Mediterranean has a far less tidal range. The currents which will thus be created by evaporation and tide will be sufficient to assist or retard navigation, as they will probably approach, if not exceed, two miles per hour, but they will scarcely be strong enough to affect injuriously the bottom or sides of the channel through the Chalouf cutting after the proper protection by stone pitching has been carried out.

It is possible that a strong south wind may somewhat increase the velocity of this current by slightly raising the ordinary tide at Suez, and that lateral absorption, evaporation, and waste round the shores of the Bitter Lakes into, and through, the sand of the desert may increase the amount of the water to be daily supplied; but these disturbing causes will not probably be sufficient to make any appreciable difference in the velocity. It would, however, have been desirable, in my opinion, that the canal should have been originally constructed on enlarged dimensions between the Bitter Lakes and the Red Sea, if the resources of the company had permitted.

Traction Power to be Employed on the Canal.—A special committee, or commission, has been engaged for some time in investigating this question, and has considered many expedients and suggestions. At one time it thought that a continuous chain along the bottom of the canal, similar to that used for the ferry at Portsmouth, would be applicable, but it is now understood that steam vessels (except those with paddle-wheels) may use their own power, and that any vessel may be towed through the canal by steam tugs, the speed to be limited in all cases, as may be settled hereafter. This is doubtless the best decision, both for economy and convenience.

Several important questions suggest themselves in the working of the canal, such as the impossibility of two large vessels passing each other until the canal is enlarged; but this difficulty must be dealt with by regulations very similar to those adopted on a single line of railway. If, however, the traffic should rapidly become very large, it is possible that several passing places will have to be provided without waiting for the widening of the whole canal.

A strong side wind would also be a considerable difficulty, and occasionally it may be found to be almost impossible to keep a large vessel from the sides of the canal. In the Caledonian canal it is well known that this difficulty is frequently experienced even with small vessels, but in Egypt very strong winds from the east and west are not common, and the difficulty will probably not amount to more than a simple retardation of the speed of the vessel, and the necessity of lowering all masts and rigging capable of

being lowered, but one or two attendant tug vessels, when required, can be made available for the purpose of enabling a vessel to keep the channel of the canal. Doubtless many unexpected matters, both of difficulty and convenience, will develop themselves in the working of the traffic, but these will be best dealt with as they arise.

PROBABILITY OF THE USE OF THE CANAL.—The Suez Canal is so peculiar in itself and in the manner in which localities are affected by it, with respect to their maritime distances from each other, that it is almost impossible to foresee the manner and degree in which it will attract traffic to itself. It may, however, be assumed with tolerable safety that, provided the canal be maintained in full depth and efficiency, and the charges made for its use are not unreasonable, the steam passenger and mail traffic now carried on between Europe and India will chiefly pass through the canal. It may with equal safety be assumed that sailing vessels, which would not only require steam tugs through the canal, but also down the Red Sea, will not use the canal. A certain amount of local traffic between the Mediterranean and Red Sea ports will no doubt use the canal.

The great element of uncertainty, and one on which the commercial success of the Suez Canal will chiefly depend, is whether new sailing vessels, with adequate auxiliary steam power, specially adapted to the canal and the Red Sea, will be constructed, so as to divert the large traffic now being carried around the Cape. I think enterprising firms will try this experiment, and if successful, the Suez Canal will secure a great position both for usefulness and profit.

ENGINEERING IN SPAIN.

FOREIGN CAPITAL AND TALENT—BAD RAILWAY MANAGEMENT.

From "The Engineer."

No country owes so much to foreign labor, foreign science, and foreign capital as Spain. Indeed, it is wonderful that English, French, Belgians, and Hebrews, should have done as they have done for a country where the peculiar nature of the soil and the eccentric character of the inhabitants must have presented difficulties at every step. The credit of having introduced the railway system into Spain is divided between an English engineer, Mr. Vignoles, a Jewish banker, Mr. T. Péreire, and the late M. Perdonnet. The latter, by the way, made a serious mistake, when he said, "Railways will change the aspect of that country." They have no more altered the customs of the Spaniards than the recent revolution has altered the state of the "*Caminos de Hierro.*" As to the construction of railways, and their subsequent repairs and management, the Spaniards have had very little to do with them. The lines were surveyed by foreigners for a good reason, namely, that very few Spaniards are sufficiently acquainted with the exact sciences to make a correct plan or to level a trial line.* The rails, turntables, switches, &c., were supplied by English or Belgian iron-works. The rolling stock was supplied partly by English, partly by Belgian and French builders. Several Belgian firms are said to have supplied rolling and permanent stock to Spanish railway companies on condition of taking part payment in shares or bonds, a transaction which has proved ruinous to them, notwithstanding the government guarantee.

The working of railways has been left as much as possible, for obvious reasons, in the hands of the native functionaries. Gentlemen of this class are as numerous and as zealous in Spain as they are now in France, or as they were twenty years ago in Austria. Railways under official management are easily recognized. Mail trains arriving at Madrid five or six hours behind time;† express trains carrying cattle and metals, as we have ourselves seen on the "Norte"; passengers turned out of their trains at night, and obliged to wait two or three hours in the open air, without refreshment or shelter; trains starting before the advertised time of departure. Such is Spanish management. And these irregularities are so frequent that they have become regular, punctuality being the exception. Native passengers do not complain as often as might be expected, because they are, as yet, not sufficiently acquainted with railways to know what they should be, and what services they might render under proper management. Wherever a large foreign staff is employed—as on the Ciudad-Real and Badajoz line—punctuality and even comfort may be expected.—The labor supplied to Spanish railway com-

* This is certainly not true of the same race in Cuba. The study of engineering is very largely and thoroughly pursued by Cubans, in our scientific schools, especially in the oldest if not the best of our engineering schools—the Rensselaer Polytechnic Institute.—*Ed. V. N.'s Mag.*

† This frequently occurs on the southern lines.

panies is divided between English platelayers, French fitters, Piedmontese underground excavators, Belgian openwork excavators, and Spaniards, who excel in no particular trade.

Spain possesses a very rugged and barren soil, but the mines of the Peninsula are very rich; and some of the richest are, by a sort of natural compensation, in the most barren districts. Coal, iron, copper, and lead ores are very abundant. Santander exports large quantities of "red ore" to the Welsh iron districts. The colliery (Cuenca) of Belmez, situate in the Sierra Morena, between Castuera and Cordova, appears likely to prove very rich. We believe that all the coal consumed by the "traction" of the Ciudad-Real and Badajoz line is supplied from this mine, though it has not been worked long. The Cuenca of Belmez was surveyed by French engineers some years ago. It is now conceded, together with the Badajoz line, to a French company (Fines-Lille.) The oldest mine in Spain in probably that of Almaden (mercury); that is worked, we believe, by Spaniards. Almost all the others are surveyed and managed by foreign companies, foreign engineers, and foreign work men. The mines of Thelva, Tarsis, Rio Tinto (copper), and Alcañces (tin), were surveyed and claimed by a French engineer—M. Ernest Deligny—and put into working order by a French capitalist—the Duc de Caze. Huelva is now in the hands of an English company.

The harbors of Spain have not given much employment to foreigners. The big moles of Tarragona, Barcelona, and Cadiz, were made entirely, we believe, without foreign assistance, and paid for by the State. But the canals have required foreign engineering talent and foreign capital. Thus Spain is indebted to foreign nations for her mines, railways and canals. She is also deeply indebted to them for money, the Spanish government having frequently issued loans, which have been subscribed in a great measure by English capitalists. Three countries especially—England, France and Belgium—have assisted Spain in such a manner as to give substantial proofs of their goodwill towards the Spanish nation, and of their confidence in the traditional honor of the Spaniards. Unfortunately the late government have destroyed that confidence and repudiated their engagements with such coolness as to induce a suspicion that they never intended to fulfil them. We may reasonably hope that the present government has better intentions and a more honorable character; but it will be a hard task for the provisional or any other administration to restore the national credit.

Converting Cocoa-nut Husks into Fibre.—The "Mechanics' Magazine" thus describes the process: The shell or outer covering of the nut is first soaked in a tank of water kept warm by steam. When sufficiently soaked, the shells are conveyed to a hopper, through which they are fed to a crushing mill, which consists of two coarsely-fluted rollers, between which the shells pass and are crushed. They are removed thence to the fibre mills. Here the shells are drawn in between two rollers, behind which are arrangements for tearing away the finer fibre and leaving the coarser in the hands of the operator, who presents first one and then the other half of the shell to the action of the mill. The coarse fibre is then carried away and prepared for conversion into brushes and brooms. The finer portions of the fibre are removed from the mill, and undergo a process of final dressing. This is effected by feeding them through a hopper into a circular screen, in which an Archimedean screw rapidly revolves. The fine fibre is delivered at the mouth of the screen, whilst the dust and smaller particles of fibre are carried through the sieve. The fibre thus produced is used for making mats and matting; the siftings find a ready sale with florists and market gardeners for manure. The sweepings and refuse are collected and burned under the boilers.

Engineers and Architects.—The kind of tacit estrangement which now exists between architecture and engineering, imperils public interests, and results in the abuse of popular taste. The engineer can no more afford to work without the architect on his great works than the architect in similar case can dispense with the engineer. In the one case we are threatened with mere size and solidity, without sightliness; and in the other, with works which promise an antiquarian rather than a true artistic interest as productions of our own day; while the art of the architect threatens to fail in its highest aim—the elevation of public taste and the excitement of popular sympathy—because it refuses to bend to the wants and discoveries of the time.

It is in no sense derogatory to the prestige and honor of either profession that the public should long to see the divorce between them annulled. Each has its special excellence and its special province; we only desire to insist that the intellect of both is essential to great and lasting successes in our public structures of every class. Life is far too short in our day, the competitive principle too active, and the exigeant demand for speedy execution of our work too pressing, to allow of any one man achieving high excellence in the character of architect and engineer at once, as we now understand the high functions of the two professions. Your modern engineer can as little be expected to design a town hall or a cathedral up to any noble mark, as your architect can be asked to construct a suspension bridge or a railway station on a grand scale. There may be, and have been, here and there, eminent instances of men gifted with the rare combination of engineering and architectural talent; but they are so scarce and so far between as not to affect our argument. How many architects, for example, are there among us to-day, who could, *de novo*, and without existing models, at once design *and* construct a Westminster Abbey or a St. Paul's Cathedral? Similarly, it may be asked, where is the engineer who could construct *and* design them? The architect may be able to design, and the engineer to construct works of such a mark, but it is idle ever again to expect that either can do both unaided by the other.—*The Architect.*

PERMANENT WAY OF THE PENNSYLVANIA RAILROAD.—It is highly gratifying on many grounds—comfort, security and engineering fitness—to strike the new permanent way of the Pennsylvania railroad, after rattling over the tracks of various roads farther east. The smoothness, the apparent absence of joints, the sailing motion, in comparison with the hard gallop of wheels over unfastened rail ends, is even better than English railway riding, because of the lateral and vertical articulation of American cars. The steel rails of this line, now in use and coming into use as fast as the Pennsylvania Steel Works can turn them out, are four and one-half inches high, four inches wide on the flange, and weigh 67 lbs. per yard. This height gives room for a thoroughly good fish-joint. The sleepers are two and one-half feet apart centers, laid on good ballast—generally blast-furnace cinder.

RIVER FLOODS.

LACK OF PREVENTION—DESTRUCTIVE EFFECTS ON PROPERTY, HEALTH, SEWAGE AND DRAINAGE.

In this country, perhaps less than in England, annual sufferers by flood take marvelously little pains to keep their property and dwellings out of reach of inundations, and still less to change the beds of streams and the defences of banks to avoid their destructive effects. The following considerations on the subject are from "The Engineer:" Once a year at least, and frequently oftener, inundated lands and submerged fields testify to the total absence of restraint imposed upon our rivers and streams, and the fury with which they exercise their uncontrolled depredations. Bearing in mind the patient passiveness and apathy that mark the conduct of the owners and occupiers under these annual inflictions, one might almost be inclined to believe that, instead of ruin and devastation constituting their invariable attendants, they were accompanied with the same advantages that follow the periodical inundations of the fertilizing Nile. Not only are the overflowing waters permitted to extend their ravages over outlaying districts and the open country, but there are very few towns where any provision is made to check the progress of floods and arrest the violence of the torrent. It is only the other day that Manchester finally decided, when driven to extremities, that something must be done in the matter, and has undertaken the construction of the necessary works, under the advice and superintendence of one of our most eminent hydraulic engineers.—If—in the case of towns—precautionary measures are adopted only after so much hesitation, procrastination and uncertainty, it is difficult to predict the period at which, the evils resulting from floods in the open country will undergo any permanent abatement. The embankment of a river for that portion of its course running through a town improves the river itself, and a handsome wall adds to the appearance of a city. But beyond this no good is effected. Above and below the wall-bound stream the waters remain in their state of original liberty, ever ready, upon the first addition they may receive to their turbid contents, to break out into open rebellion. It is even questionable whether the penning up, as is were, of the contents of the swollen channel, does not increase the violence of those portions of the

stream unconfined by the granite boundaries. That the improvement—whether it consists of widening, narrowing, strengthening, or deepening the river—is confined altogether to the small portion affected, there can be no doubt. It is apparently incredible that we, who, in the nineteenth century, have rendered all the powers of nature obedient to our will and subservient to our interests—we who have made the opposite elements of fire and water administer to our comforts and contribute to our welfare—should permit our rivers and streams to range at large unchecked and unrestrained, and annually to commit ravages costing thousands to repair.

It is not our province to inquire into the reasons why houses come to exist in such close contiguity to rivers notorious for inundations, or why people elect to reside in abodes, which are reared upon so fearful a source of sickness and death as damp foundations. It has been lately advocated by a well-known authority, that every dwelling house should stand upon its own area of concrete or other waterproof substratum. The mere insertion of a course of slates, a layer of asphalt, or a coat of cement above the footing course, is not sufficient to endow a house with immunity from those evils which directly result from too close a communication with a damp soil. Unquestionably the true principle is that which would require the whole of the area, upon which the building is raised, to be overlaid with a waterproof layer; and we trust that we shall ultimately witness the enforcement of this proviso, by the authorities charged with the supervision of the erection of new buildings.

There is another light in which to view the evil results springing from the wholesale inundation of arable and fertile land, which materially affects the great question of sewage irrigation. It is often urged that it would be impossible to apply sewage to lands that are particularly well situated with regard to levels, and in other respects admirably adapted for its reception, owing to the great quantity of water existing in and about them. The agriculturist exclaims, "We have more water than we know what to do with, and you want to send us a still larger supply!" This brings us to a consideration of another feature in connection with the utilization of sewage, which is not regarded with the attention it deserves. It is the question of drainage. Lands subject to periodical floodngs must necessarily present greater obstacles to the carrying out an efficient system of drainage, than others more favorably located. One of the first steps taken at Barking was thoroughly to drain the subsoil; and, in fact, this operation was carried out to a greater extent than was absolutely required, as experience subsequently demonstrated. In an instance of the nature alluded to, it will, nevertheless, be admitted that it was better to err upon the safe side. A work of supererogation was infinitely preferable to the fault of omission. If a farmer will not go to the expense of draining his land and putting it in proper order to benefit by the application of sewage, he cannot in common fairness, allege that the non-utilization of that fertilizing medium is due to a self-inherent defect. Moreover, supposing that all the lands subject to inundation were properly drained, yet the overflowing of the natural water-courses would, for a time at least, effectually prevent the application of sewage. From the statements already made, it is manifest that by the annual outbreaks of our rivers and streams, many thousands of acres are either permanently or temporarily prohibited from benefiting by the application of sewage. What constitutes a further aggravation of the evil is that these very lands—from their physical features and natural position—are calculated to receive the sewage by the readiest and cheapest method possible, namely, that of gravitation. We could point out instances where land situated along the banks of the Medway, and, in every sense well adapted for the utilization of sewage, cannot be so employed in consequence of the floods to which it is constantly subjected

It would scarcely be reasonable to urge that all rivers should be prevented from trespassing beyond the limits of their natural channels, by the erection of heavy walls similar to those constituting part of the Thames embankment. At the same time, there is not the slightest doubt but that in numerous instances, especially in those localities where labor and materials could be procured comparatively cheaply, it would pay, in the long run, to construct a sound strong wall, instead of the stereotyped bank with its central core of puddle and inner and outer slopes. Only those who have had the care of these banks are acquainted with the watching they require, amounting at times to a regular patrolling. They are a continual source of anxiety and annoyance to the proprietors of the lands protected by

their ambiguous influence, and a never-ending cause of expenditure.

There is no question but that the tortuous course of some rivers, the multiplicity of twists and abrupt bends, mainly contribute to the occurrence of floods. It is in the "elbows" that the marshes and swamps principally exist. If we imagine a rapid torrent coming down a straight reach, and on a sudden encountering an abrupt bend, nearly at right angles with its previous course, the volume of water cannot adapt itself to the sharp sinuosity, but overleaps the bank, floods the land situated in the concave part of the "elbow," and whatever is left of it falls into the channel beyond the bend.—Were more attention paid to improving the course of our rivers and the cross section of their channels, the work of the banks would be considerably lightened. As it is, they have not merely their legitimate duty to perform as confining or retaining walls, but in the majority of instances they have to withstand a pressure and violence which ought never to be brought upon them, which is due to the crooked character of the river's course. Floods are due, not so much to the gradual rising and swelling of the waters so as to uniformly overflow the banks, as to the fact that they accumulate with a rapidity exceeding that with which they are able to get away. Owing to the impediments in their course they become piled up, as it were, at certain points, to a height far exceeding that of their confining banks, while at others their level is scarcely perceptibly altered. If a little more money were spent in widening, straightening, and deepening the defective portions of our rivers and streams, we should hear less of banks being breached, meadows flooded, and towns inundated.

COAST DEFENCES.

From a lecture by Col. Jervois, before the Royal Institution.

Coast defences in Anglo-Saxon times consisted, in the main, of predatory incursions and plundering expeditions. The progress of civilization has introduced better usages into the practice of modern war; but if it had not, the length of our coasts is far too great, and the accessible points far too numerous, to render it possible to fortify them all. When we speak, therefore, in the present day, of our coast defences, we must not be understood to advocate a vain attempt to secure by defensive works every vulnerable point, but to provide for the protection of our national dockyards and arsenals, and of our main commercial ports.

For the general defence of a vast empire we must first of all, and mainly, depend upon our fleet. It is to the fleet we must look for our first line of defence against invasion, to maintain our communications with our foreign possessions, and to protect our commerce at home and abroad. But the bases on which our naval power must rest are the ports, dockyards, and arsenals, in which our fleets and squadrons are harbored, coaled, and refitted. Thus we have naval establishments at Portsmouth, Plymouth, Chatham and Pembroke, at home; at Bermuda, Malta, Gibraltar, and other places abroad.

These places are the roots from which our naval power springs, and they require special protection against attacks that may be made upon them during the absence of the fleet, either by hostile naval forces alone, or by combined naval and military expeditions. Even if it were possible that a fleet sufficient to fulfill all these duties could be maintained, such an application of the resources of the nation would lead to an expenditure of public money, far exceeding that which would suffice for the defence of the country with the aid of other means. Further, if the several sections of our navy were employed for the protection of the arsenals whence they are maintained, we should be using the fleet to maintain the dockyards, instead of the dockyards to maintain the fleet.

The means by which these places should be defended are by big guns above water; big mines below water, placed at proper distances in advance of the object to be defended. It used to be the fashion amongst professional men in this country to consider this latter mode of defence as being incapable of practical application, but of late years a very different opinion has prevailed; and through the efforts of Lord De Grey's committee we are now in a position to apply this system of defence to any extent that may be required for the protection of our harbors and other points upon our coasts. The question then arises, how far, if at all, does the use of the submarine mines affect the employment of forts and batteries for defence against naval attack. Forts and batteries are still required in all important cases to cover the torpedoes, and prevent their being tampered with. It must also be remembered that

whilst the submarine mine is harmless unless the ship comes near it, the shot from the battery can injure the ship, whatever may be her position, within effective range. Further, although probably our harbors might be efficiently obstructed by torpedoes at from seven to fourteen days' notice, yet one condition is that the weather should be sufficiently favorable to allow them to be exactly laid. There are, again, certain positions where, even if the torpedoes were laid, they might be disturbed by a violent storm, and possibly an attack on the positions in which they were to serve might take place before they could be renewed; and although the periods of the year at which these difficulties might arise are short, yet the bare possibility of interference in the application of a complete torpedo system prevents our placing entire reliance on such a defence for the protection of places on which the warlike power of the nation, both for offence and defence, must in a great measure depend. Therefore, although submarine mines are a most important element in the defence of our harbors and coasts, and add greatly to the power of our forts to resist a naval attack, they must not be regarded as substitutes for permanent works of defence at our naval arsenals and harbors, and of our important forts.

To proceed now to consider the employment of big guns above water. These, with all the numerous accessories for their service, must be placed in positions so protected and arranged as to give them a decided superiority over the artillery of assailing ships. The question then arises, whether they shall be placed afloat in strongly protected vessels—*i. e.*, in floating batteries—or at fixed points either on land or on shoals—*i. e.*, in forts. It is often said, "Why don't you protect your ports by floating batteries alone?" The same reasons, however, as have been before adduced against the employment of our sea-going navy, prevent our employing special floating batteries for this object. It would necessitate our maintaining, at each of our chief ports, a naval squadron sufficiently powerful to resist the attack of superior forces of the enemy.

In the construction of coast batteries two main points have to be attended to: 1. To give cover to the guns and gunners. 2. To develop, as far as possible, the lateral range and rapidity of fire of the guns. These two principles being somewhat antagonistic, has so far always been one of those difficulties to be reconciled, and it is to the fluctuation in the relative importance of cover or fire, of protection for offensive power, that different designs for coast batteries are due. The simplest form of battery is a mass of material in front of the guns, and either of earth, masonry, or concrete, according to the circumstances of the site. It is evident that the greatest extent of range may be obtained from the guns if they are so mounted as to fire over this parapet—or, as it is called, *en barbette*—for their field of view is entirely unobstructed, and this simple system is well adapted for sites at considerable elevation, say 100 feet above the water, where neither the guns nor gunners would be much exposed to the fire of a hostile vessel. When, however, the site is low, the enemy's view of the guns in a barbette battery would be such that he would easily silence the battery; and it has therefore been necessary in such situations to mount the guns so that they may be fired through openings or embrasures cut in the parapets, instead of firing them over the parapet. The Moncrieff gun-carriage has solved many of these difficulties; but armored and covered defences are, nevertheless, essential under many circumstances, so that the fort might be protected properly from every species of attack.

The question of the defence of our great naval arsenals, in the event of an enemy obtaining a footing on our shores, was next discussed. It would, to say the least, be very unwise if we were to conclude that invasion is impossible because it is difficult. The best disciplined and the greater part of our military forces must obviously be employed to cover the capital; we must, therefore, arrange our plan of defence so that as few disciplined troops as possible may be necessary for the defence of other points in the country which must be defended, but which cannot be covered by the operations of the main army. A mistake is commonly made that because the arsenals and yards referred to are extensively fortified, the garrisons of those places must be largely increased. The case is precisely the reverse. Supposing all the outer line of forts to landward, at either Portsmouth or Plymouth, to be fully manned at the same time, (which would be quite unnecessary, not more than one-half need be fully manned at the same time.) only between 6,000 and 7,000 men would be required for the purpose at each place

respectively, and only a very small portion of these need be regular troops. The remainder of the garrisons would consist of a movable force, which in any case we must have for the defence of these places, but which, in the absence of the forts, must be of sufficient strength and sufficiently disciplined to meet the enemy in the open field, whilst with the forts it may be comparatively small in number, and only disciplined to take up a fighting position, under the support of the works at that part of the fortified line assailed. Unfortified, an enemy would only have to detach from the main invading army about 15,000 or 20,000 men to effect, in a few days, the destruction of all our ships and naval establishments at Portsmouth. Fortified, he must employ an army of at least three times that number, and must have a considerable time at his disposal to undertake a regular siege. Unfortified, no force that, in the case referred to, we could afford for the garrisons of these places could protect either against the attack of 15,000 regular troops. Fortified, there is no difficulty in providing the numbers and description of troops that would be capable of making a good defence of these nurseries of the navy. Unfortified, they at once fall if an enemy were to obtain a decisive victory over the army in the field. Fortified, they remain in our hands even under such untoward circumstances, and thus enable us to avert the destruction of our naval power at a period when all the resources of the country will be required to enable us to retrieve the position we had temporarily lost.

We are often told that these works are unproductive, and so, in one sense, they are; but who shall say what effect permanent measures of defence may have upon the position of a nation. But we are met with other objections. It is commonly said that there is no use in constructing permanent fortifications, because the inventions of one age render useless the efforts of the previous generation. History, however, does not support this statement. At this moment we are turning to account, and with good effect, works erected by Henry VIII, more than three centuries ago. In like manner the works constructed in the time of Charles II, and in the reigns of George II and George III, all more or less form parts of the system of fortifications we are adopting at the present day. Then we are told that the measures are so extravagant. The fact, however is, that by the aid of fortifications we are enabled to defend the empire with fewer troops and a smaller navy than would otherwise be necessary, and that they thus tend greatly to economy. If we are to make provision for defence at all, it is only by the aid of fortifications that we can have an economical system of defence. They say, then, that our fortifications "lock up" troops. It has been shown, on the contrary, they enable us to utilize our auxiliary forces, and to set the regular army free. Again, we are told that we ought to depend upon our navy; but the main purpose of the fortifications is to enable the navy to do its duty effectively. The navy is, without doubt, the arm on which we must mainly depend; but that is no reason why we should tie it down to our side. Lastly, they say "an enemy will not go near these fortifications." The reply is, that that is the very object for which they are provided. To sum up, the truth is, that to provide an efficient system of defence at the least cost to the state, the soldier, the sailor, and the military engineer, must each occupy his proper place. The navy and the army are the vital principle of defence, and fortified arsenals and harbors are the centers of refuge and action for both. Take away fortifications, and you are unable to turn your auxiliary forces to proper account; you leave an army utterly insufficient for the duties it has to perform—a navy scattered, unsupported, and with no protected home.

DURABILITY OF STEEL RAILS.

It is officially stated that out of the eleven thousand tons of steel rails in use on the Hudson River Railway—some of which have been down over three years—only eleven rails had broken up to January 1, 1869.—One broken rail to the thousand tons, is rather a different matter from a thousand broken rails a month, which was the breakage of iron rails on the Erie road last winter.

On the Erie road it is officially stated that only ten steel rails have broken out of the eight thousand tons in use. Some thousand tons of the above mentioned steel rails were made at Troy—the rest are of English manufacture. The success of steel rails on the Lehigh Valley road is mentioned in another article.

The following letters from the President of the Philadelphia, Wilmington and Baltimore Railway give a complete history of the trial and use of steel rails on that road:

P. W. & B. R. R. Co., PRESIDENT'S OFFICE, PHILADELPHIA, Dec. 16, 1868.

EDWARD AUSTIN, Esq., Boston:

Dear Sir—Your letter of the 15th inst. is before me. This company commenced the use of steel rails made at the Atlas Works, Sheffield, England, by John Brown & Co., in August, 1864. At present we have laid and have in use upon the most trying portions of our line, about twenty-five miles of single track of same make. We have never broken one in use, nor taken up one on account of wear or defect. In the middle of a much used portion of track laid with steel in 1864, near Philadelphia station, we laid one rail of American iron, and have replaced it, as needed, by other rails of American iron, until we have used up sixteen iron rails, while the steel will wear for several years yet. My last information as to condition of track, shows that not one steel rail in twenty-five miles of track shows any imperfection or defect, but all are wearing truly and smoothly. No observant passenger will fail to detect the passage of a train from steel to iron, and vice versa. I cannot speak of makes other than Brown's, nor do we fail to inspect his *rigidly*. I have rejected 88 tons from an invoice of 600 tons. Mr. Joy's* failures may have been of other manufacture. They may not have been well inspected; they may have been punched or slotted, or any one of many other good reasons may be adduced for their failure.—But my experience is enough for me. On a road like this, where our iron does not last seven years on an average, true economy, as regards the rail expenditure alone, demands steel rails. The reasons which limit our purchase of steel to about 50 per cent of our renewals, are found in our poverty alone.

We were long since led by our experiments to the conviction that punching and slotting were very injurious to steel rails, and for two years we drilled them as the lesser injury. We now use a joint fastening which dispenses with all holes in the rails.† My last purchases of Atlas rails were at $100 gold, in Philadelphia, to be delivered in 1869, and of Welsh iron rails, guaranteed five years, at $83 currency in Philadelphia. I have also received 100 tons Barrow steel on trial, and have a contract for 500 tons Pennsylvania Steel Company's rails. We have also in use 500 tons steel headed rails made in Pennsylvania,* costing $113 currency, which promise well. I am offered steel rails of other makers at $92 gold in Philadelphia, but have completed our purchases of iron and steel rails for 1869.

The freedom from a defect in a track means also diminution of cost of repairs of locomotives and rolling stock, and enhanced safety of passengers. If we go on laying ten to fifteen miles per annum in steel, you will ere long see that our expenses for track repairs and in our shops, will be reduced considerably. While we are buying steel rails and charging their cost to "repairs," that account must be large. * * *

Very truly yours,

(Signed) ISAAC HINCKLEY.

P. W. & B. R. R. Co., PRESIDENT'S OFFICE, PHILADELPHIA, Dec. 22, 1868.

EDWARD AUSTIN, Esq., Boston:

Dear Sir—I have yours of the 18th. The first steel rail imported has already worn out sixteen (16) iron rails, and we have not now any reason to suppose that the latter invoices are of inferior quality. But there is great fear on my part, that railroad companies will themselves tempt steelmakers to send a poor article, by buying the cheapest—first cost only considered—as they did with the ironmasters. It rests with railroad men to keep steel rails good by buying no poor ones.

We try steel with the chisel for *hardness*, with the trip-hammer for *toughness*, and for *strength* with the 2,240 lb. drop, fifteen feet, the rail resting on supports three feet apart. Rigid inspection only can save us. Having passed inspection, make no holes, or at all events, no *punched* holes in the rails.—Punching is bad enough for iron, but death to steel.

We, on Friday last, dropped our 2,240 lb. "tup" twenty (20) feet, upon a steel rail resting on supports three feet apart. The rail was merely bent. I have in my office a steel rail twisted, *cold*, into a regular spiral of one entire turn to two feet length, without crack or flaw.†

Very truly yours,

(Signed) ISAAC HINCKLEY.

* Michigan Central Railroad.
† Reeves' new Joint.—*Ed. V. N.'s Mag.*

* Waterman & Beaver's puddled steel heads.—*Ed. V. N.'s Mag.*
† We have twisted rails made by the Pennsylvania Steel Company, and by John A. Griswold & Co., as here stated.—*Ed. V. N.'s Magazine.*

HISTORY OF DECARBURIZING IRON.*

No. II.

HEATING THE IRON TO BE MELTED, BY THE WASTE HEAT OF THE MELTING FURNACE —CAST IRON FURNACE FLOORS—HEATING BOILERS BY THE WASTE HEAT OF FURNACES.

GARDINER, ROBERT.—1788, June 5. No. 1,608.

Printed, 3d.

Manufacturing iron and other metals by a progressively multiplying air furnace. A series of compartments connected by flues from the multiplying furnace, and the flame and heat pass from one to the other. Each has a separate door, the further compartment being less hot than the more near; the first may be at a welding, the second at a red heat, and the third at a less heat, or if required, may be raised to a greater heat by adding another and separate fire communicating with the common flue. The waste of putting cold iron into the melting furnace is avoided, as it may be heated by the waste heat in the extra compartments ready for use.

Cast iron floors for the furnaces save the wear of the old sand floors.

Steam boilers may be heated by passing the waste flame and heat from the furnaces, round, under or through them.

NOTE.—*The patent does not* SPECIFY *using the waste heat of puddling furnaces, but it* COVERS *such use, in as far as a puddling furnace is and must be a melting furnace. Jones specifies using the waste heat of puddling furnaces in* 1822. (See p. 359.)

This patent is only four years after Cort's invention of puddling. It mentions iron furnace floors for the first time.

It is remarkable in specifying, 81 *years ago, the heating of boilers by waste heat—a thing which is claimed by several modern mill managers.*

OXIDE OF MANGANESE USED IN THE CONVERSION OF PIG INTO MALLEABLE IRON.

REYNOLDS, WILLIAM.—1799. December 6. No. 2,363.

Printed, 3d.

"Preparing iron for the conversion thereof into steel." The invention consists in the employment of oxide of manganese, or manganese, in the conversion of pig iron into malleable iron or steel. No proportions or details are given.

NOTE.—*This is the first mention of manganese in the Patent Office records of the iron manufacture.*

THE SQUEEZER.

HARTOP, JOHN.—1805. November 7. No. 2,888.

Printed, 3d.

"Method of preparing malleable iron, &c." The invention consists in the use of a kind of squeezer worked by a cam instead of a forge hammer or rollers.

NOTE.—*This is the first mention of the squeezer in the patent records.*

INTRODUCING AIR BLAST ABOVE THE GRATE.

DIMMACK, JEREMIAH.—1812. May 26. No. 3,569.

Printed, 3d.

"Manufacturing iron in its difficult stages or forms of blooms, slabs, piles, bars," &c., "or other malleable iron from pigs or plate iron in a puddling, balling, bloom, mill, sheet iron furnace, or any other air furnace," &c. "Take any furnace of the common construction," but the grates must not be large, and "less at one end than the other." "Level with and immediately above the top of the grate," introduce an iron blast pipe, with stopcock to regulate and shut off the blast, and put dampers in the chimney.

NOTE.—*Although referring, among other things, to the manufacture of malleable iron from pigs in a puddling furnace, this practice, as far as it supplies air above the fire, would not meet the modern idea of puddling, viz: decarburizing by means of the fettling, without the aid of air.* (*See Siemens on Puddling. Van Nostrand's Mag., Vol. I, No.* 1, *page* 37.) *Blowing in air above the fire in reverberatory heating furnaces is, however, practised in some of our best modern forges, especially for heating large masses. This patent at least hints at this practice.*

IRON ORE, SCALES, LIME, ETC., USED TO DECARBURIZE PIG IRON.

MUSHET, DAVID.—1815. July 27. No. 3,944.

Printed, 4d

The metallic contents of refuse, such as slag, scoria, cinder, scales, &c., are recovered and made available for producing "finers' iron or metal" in a furnace, called "a smelting finery," by "making use of the superfluous carbon" in pig iron, which is to be melted with the refuse in the following proportions: 300 or 400 lbs. of coke, 600 lbs. of pig iron (broken up), 180 to 240 lbs. of refuse and 150 lbs. of limestone, or by preference, 40 to 120 lbs. of burnt lime. When the charge is melted, the metal sinks to the bottom, and should be kept carefully covered with the melted scoria; no part is to be run off till the furnace is tapped. If, after the first or second tapping, the metal is not sufficiently decarburized, or "not high enough blown," the proportion of coke is reduced, or that of refuse increased.

* We omit several patents clearly and fully anticipated in previous specifications. The specifications referred to are printed and generally illustrated with plates. We append the price to each. They may generally be obtained from the Patent Office in London, through any American publisher. Editions are sometimes out of print for a few months, but new editions are issued from time to time. Those referred to in our former article are all printed. The price is 3d. each, except Onions', which is 7d. All the British specifications and engravings are on file and free to inspection at the Astor Library in New York and at several other libraries.

2d. Instead of "refuse," iron ores may be reduced in a similar manner, with mixing them with pig iron, the ores being thus used for decarburizing the pig iron either in their raw state or calcined.

3d. Instead of the above charge, pig iron may be omitted, and 350 to 450 lbs. of coke or other fuel, 300 to 350 lbs. of refuse, and 100 to 120 lbs. of burnt lime, or 140 to 170 lbs. of limestone, melted together, will produce finers' metal. The proportion of lime should be with mill scale one sixth, mill or balling furnace slag one third, puddling and finery slag one fourth of their respective weights of burnt lime.

4th. To produce metal from iron ore, 300 to 400 lbs. of coke, 300 to 350 lbs. of iron ore (broken small), and as much lime as would flux the ironstone in an ordinary furnace, are used.

5th. With proper proportions of flux, refuse may be used either with ironstone or iron ore, care being always taken to have a sufficient depth of scoria to protect the metal. "By having a hearth of sufficient depth below the twyre, part of the scoria may be run off, and a greater quantity of metal be obtained at one tapping."

6th. If the materials of the charge are sufficiently fusible the quantity of coke or other fuel may be diminished, or the amount of refuse increased, till "the proper degree of decarbonation" is obtained. Waste is thus lessened, since "the higher the iron is refined or blown, the less is the loss or waste in the subsequent manipulations of the forge."

7th. The metal may be kept protected by a sufficient depth of scoria "by drawing off the metal from below," instead of "allowing it to flow off above," thereby requiring less blast.

The furnace recommended for the smelting refinery is similar to a common blast furnace, but smaller, with a square or cylindric hearth, having a height of about twenty to thirty feet, six to eight feet in diameter at the boshes, two to three feet diameter at the top; the hearth being five or six feet high, and two to four feet in diameter.

NOTE.—*At this time of excitement about the Ellershausen process and the ore processes it has given rise to, it is interesting to remember that both ore and other oxygen-bearing substances were specified, to partially decarburize pig iron, over half a century ago—not in the puddling furnace, but in a sort of finery or first stage of puddling. The use of the ores is clearly stated in the 2d paragraph above.*

PARTIAL DECARBURIZATION BY MEANS OF AIR JETS, WITHOUT THE USE OF FUEL.

HILL, ANTHONY. — 1817. August 5. No. 4,151.

Printed, 9d.

"Improvements in the working of iron." These consist "in causing crude iron while in a fluid state, howsoever and from whatever substance such fluid crude iron may have been obtained, to be exposed to and conveyed along with a strong current of condensed air or blast in such manner that it may be thereby minutely divided and dispersed, and expeditiously "blown and acted upon by the air." The patentee describes an arrangement of apparatus by which this object can be effected. A cullender of cast or wrought iron shaped like a bucket, being about eighteen inches in diameter at the top, and ten inches at the bottom, is supported in a case on the top of a wrought iron tube about thirteen inches in diameter, and eight feet long, called the "discharge tube," which is sunk into a well surrounded with water to keep it cool. At the top of the tube just beneath the cullender are apertures for the admission of a blast. The operation is performed as follows: The molten iron is poured into the cullender and falls through the holes into the discharge tube. At the same time a strong blast is injected into the tube in and among the divided particles of iron, which are thus subjected to its action during their descent into the well. The iron is collected at the bottom of the well, and at the end of the operation the water is discharged from the well, and the iron then "must be made into bar iron by puddling, reheating and rolling, or by any other known means."

NOTE.—*Anthony Hill is known to have been a practical iron worker, but how far he utilized this invention we have no evidence. He does not propose to decarburize the metal sufficiently to make it malleable, as Martien subsequently (September 15th, 1855) did, by less adequate means, viz: the blowing of air up into a stream of liquid iron as it flows in a runner. Neither of these inventions could accomplish anything further than refining iron preparatory to puddling, and Hill's has this advantage over Martien's—that it would work—in some limited degree.*

Hill's is the first recorded proposition to decarburize without the use of fuel to keep up the temperature, and it would appear to anticipate the claims of subsequent inventions as far as partial decarburization, without the use of fuel, is concerned. Bessemer introduced a radically new element — the MECHANICAL FORCE OF AIR *to keep the metal subdivided so that the oxygen could act on a vast surface of carbon at once, and thus burn it* FAST ENOUGH *to keep the iron liquid.*

CHARCOAL USED TO PROTECT THE BOTTOMS OF PUDDLING FURNACES.

HARFORD, RICHARD SUMMERS.—1822. January 9. No. 4,634.

Printed, 3d

"An improvement in puddling." The improvement consists in using a layer of charcoal or charred carbonaceous matter, powdered or otherwise, to "protect the cast iron bottoms or floors of puddling furnaces" from the effects of the intense heat, and substituting charcoal for the substances usually employed, such as scoria or sand, which impart injurious qualities to the iron.

HEATING THE IRON TO BE PUDDLED BY THE WASTE HEAT OF THE PUDDLING FURNACE.

JONES, WILLIAM.—1822. October 18. No. 4,713.

Printed, 3d.

"Improvements in the manufacturing of iron." The invention consists in charging the puddling furnace with refined metal, pig or crude iron in a heated state, instead of putting the charge in cold. The heating operation may be performed either by the heat of the puddling furnace or in a separate furnace.

NOTE.—*This patent is partially or wholly anticipated by Gardiner's, in* 1788. *This important improvement has long been used in some establishments, and is just now coming into very extensive use in this country. It is found to effect a considerable economy of fuel.*

THE USE OF SALT IN THE PUDDLING FURNACE.

LUCKCOCK, JOSEPH.—1824. May 15. No. 4,956.

Printed, 3d.

"An improvement in the manufacture of iron." The improvement is stated to be the use of salt in certain quantities, ascertainable by experience, to be mixed with the iron in the state in which it comes from the blast furnace, and worked up with it in the puddling furnace.

NOTE.—*Anticipated by John Payne, 96 years before, as far as the chemical effect of salt in refining is concerned, though not used in the puddling furnace. Experiments are still making, and patents are still applied for in this direction.*

THE USE OF SALT AND POTASH, IN SPECIFIED PROPORTIONS, IN THE PUDDLING FURNACE AND FINERY.

LAMBERT, JOSIAS.—1829. March 30. No. 5,779.

Printed, 3d.

"Making iron." The invention consists in the application of two parts salt and one part of potash, in the blast, or refinery, or puddling, or balling furnaces. The mixture being applied to iron of inferior quality at a high degree of heat, is stated greatly to improve it.

NOTE.—*Payne also proposed, in* 1728, *the use of potash; Lambert, however, is the first to specify definite proportions.*

SPECIFIED QUANTITIES OF SALT, POTASH, LIME AND SALTPETRE IN PUDDLING.

LAMBERT, JOSIAS.—1830. February 4. No. 5,893.

Printed, 3d.

"Making iron." The invention consists in the use of a mixture of salt, potash and lime, or a mixture of salt, saltpetre, and lime, in the smelting, or puddling, or balling processes, in all or any of them. The proportions recommended by preference are two parts salt, one of potash, and two of lime, for the first mixture, to be used when the iron is of red short quality, and for the second mixture, two parts salt, one and a half saltpetre, and two parts lime, to be used when the iron is found to be "cold short." The mixture may be introduced in the furnaces at regular intervals, or combined with every change of materials. The mixtures are used in proportions, varying according to the qualities of the iron. The following are recommended: In the blast furnace, 25 lbs. to the ton of iron; in the finery, 20 lbs. to a ton of iron; in puddling, 18 lbs. to the ton; in the balling furnace, 18 to 30 lbs. per ton.

WATER AND AIR CASINGS FOR FURNACES —THE BOILING PROCESS—DISPENSING WITH THE FINERY.

HORTON, DANIEL, and HORTON, GEORGE. —1832. September 7. No. 6,299.

Printed, 1s. 10d.

"Improved puddling furnace." The invention consists in applying to the old puddling furnaces certain additions claimed as new, viz: hollow vessels or cases forming the ends and sides of the lower part of the puddling furnace, allowing air or water to circulate in contact with the inside casing of the puddling furnace, the object being to enable a very high degree of heat to be used in the puddling furnace without its being destroyed, the injurious effects being prevented by the circulation of air or water carrying off the superfluous heat. The use of this puddling furnace (which is fully described with drawings) enables the refining process to be dispensed with. On the bottom and sides of the furnace are strewed slag and cinder to the depth of about an inch or an inch and a half. These are melted and form a bottom, on which are placed broken pig iron and ½ by weight of cinder and slag. The whole is then "raised to a higher degree of temperature than is usual in puddling refined iron, which will cause the pig iron to boil," "during which operation the same is to be well stirred" by the puddler "until the malleable iron is disengaged from the cinder." The heat, if necessary, is then to be damped off. The iron is to be balled, and the puddling completed in the ordinary way; and when the balls are withdrawn, the fluid cinder is run out, and a fresh charge is put in. Malleable iron is thus produced direct from the pig.

NOTE.—*Water casings, backs and frames have been the subjects of many subsequent patents, new, doubtless, in detail; but here is the first record of the practice, and it is quite comprehensive and complete.*

Although commencing with pig iron is specified in former patents, the finery was universally used at this time as a preparatory process.

The boiling process was introduced, apparently, to avoid the finery—to decarburize faster. It is now used to make a better quality of iron.

A SHOOT TO CARRY MELTED IRON FROM THE BLAST FURNACE TO THE FINERY.

GUEST, JOSIAH JOHN.—1833, January 31. No. 6,379.

Printed, 3d.

The invention consists in affixing to the blast furnace an iron shoot or channel, and running the molten metal from the blast furnace direct into the refinery furnace (which is placed near thereto), where the iron is refined in the usual manner.

SPECIFIED QUANTITIES OF OXIDE OF MANGANESE, SALT AND CLAY, IN MAKING MALLEABLE IRON.

SCHAFHAUTL, CHARLES.—1835, May 13. No. 6,837.

No specification. See Repertory of Arts, Vol. IV, new series, p. 334; and Newton's London Journal, Vol. VII, p 341.

"Manufacturing malleable iron." The specification of this patent appears to have been stolen.

From the following references (Repertory of Arts, Vol. IV, new series, p. 334; Newton's London Journal, Vol. VII, p. 341), it seems that the invention consisted in the use of black oxide of manganese, 1¾ lbs.; common salt, well dried, 3¾ lbs.; potter's clay, well washed, 10 oz. The ingredients are well mixed and ground fine, and fused with about 3¾ cwt. of pig iron in the boiling oven. The color of the flames will indicate the progress of the fusion. The mixture being, by preference, introduced in three portions, the result will be a good soft iron. To produce a harder iron, three or four shovelfulls of roller refuse and cinder from the balling furnace are added, and only half the quantity of manganese employed. Less quantities of manganese and more of refuse and slag will produce a harder iron.

NOTE.—*The use of manganese was first specified by Reynolds, in 1799. Schafhautl is the first to particularize proportions, which, by the way, are not very different from present practice in some localities. Manganese is now generally employed in the puddling furnace, in the shape of Franklinite pig iron, or spiegeleisen—the carburet instead of the oxide—and is found of great advantage when the irons treated are sulphurous. It is indispensable to making good puddled steel from most of our irons.*

PUDDLING WITH THE USE OF PULVERIZED IRON ORE.

MUSHET, DAVID.—1835, October 22. No. 6,908.

Printed, 6d.

"Manufacturing bar iron or malleable iron." The specification commences by giving a detailed account of the refinery and puddling processes, and the terms employed therein, and of the different qualities of cast iron. It then proceeds to describe the improvements patented, which consist in mixing finely-powdered iron ores of rich qualities with the iron while being puddled in the puddling furnace. Sometimes powdered charcoal is mixed with the powdered iron ores. The mixture is added in small doses, and promotes the fermentation of the iron, and causes it sooner to be "brought to nature." It also enables crude iron to be used without being refined, and produces a bar of improved quality and greater weight than the old processes. A charge of about 450 pounds of crude pig iron, varying in quality from bright grey and mottled to white, according to circumstances and the judgment of the manufacturer (No. 2 grey iron foundry metal will produce excellent bar iron) is employed; when it begins to melt, and is fit to be stirred by the puddler, a dose of about two pounds of powdered ore, or ore and charcoal, is sprinkled on the iron, and well stirred up with it. The doses are gradually repeated as they are absorbed, until about forty pounds of powdered ore (or one-eleventh by weight of the charge of crude pig iron), have been sprinkled on the fermenting iron. The puddling process is carried on meanwhile in the usual way. If charcoal is mixed with the powdered ore, it should be wetted. By this process, about twenty hundredweight of puddled bars are produced from twenty-one and a half hundredweight of crude pigiron of as good quality as would be obtained from ordinary refined metal. If refined metal or "plate" be used instead of crude pig iron, to a charge of 450 pounds about twenty-five pounds of powdered ore should be used, and twenty hundredweight of puddled bars are produced from twenty and three-quarters hundredweight of refined metal or plate. Other proportions and particulars are given according to the quality of the materials employed.

NOTE.—*David Mushet was the very best authority on the iron and steel manufacture at this time. Like other men of large ideas and experience, he sometimes patented or suggested very novel changes, which, although very reasonable, also, had not been worked out in practice. In this case, however, his specification was obviously drawn up after the facts had been fully developed.*

Thirty-four years ago, Mushet published the fact that stirring fine ore into iron during the process of puddling IMPROVED THE QUALITY AND INCREASED THE YIELD—*a fact that some of our iron makers have not yet found out. Coarse ore for fettling has long been used, especially in the works about Troy; but the practice is not so common in Pennsylvania and the West. Indeed, the Troy iron makers consider the Ellershausen process a greater improvement on the Pittsburg practice than on their own. But stirring in fine ore has just begun to be practiced regularly. Mushet specifies about 10 per cent of ore; as much as 30 per cent (what Ellershausen uses) has lately been used in the puddling furnace during a fortnight's steady work, with a very great economy of fuel and time, and with an improvement of quality.*

Some 20 years ago, the experiment of mixing charcoal with the ore, as here suggested by Mushet, was tried at a large American works with very good results. The practice has lately been revived. The use of carbon to aid decarburization can be explained on the ground of promoting a higher heat throughout the mass. The more carbon there is in Bessemer pig iron, the more easily is it removed; the rapidity of combustion is the great end to be sought.

A good many inventions are from a quarter to a half a century ahead of the times. The Stevenses, of Hoboken, developed or suggested nearly every feature of modern iron-clad warfare twenty years before they were taken up by Governments. In fact, Col. John Stevens made drawings of an iron-clad ship for the defence of New York in 1812, which was 43 years prior to the first use of iron-clads in naval warfare. Mr. Mushet was equally in advance of the times, not only in his practice mentioned above, but in other directions to which we shall have occasion to refer.

MECHANICAL PUDDLING.

SCHAFHAUTL, CHARLES.—1836, June 13. No. 7117.

Printed, 9d.

"Apparatus for puddling iron." The specification and drawings describe an apparatus for working the stirring rabble, and giving it the necessary longitudinal and transverse motions in the puddling process.

NOTE.—*Considering the fact that this process is likely to come into use soon in this country, these old patents (this is the first record on the subject), are likely to be interesting, and we commend their perusal to the one hundred and one geniuses who will apply for rabble moving contrivances as soon as the thing is likely to be in demand.*

THE DRYING OF PAINT.

From a paper by Charles Tomlinson, F. R. S., read at the Society of Arts.

(Continued from page 261.)

Every one knows what is expected of good paint. In the first place, it should be sufficiently liquid to spread under the brush, and sufficiently viscous to adhere to the surface, even though it be vertical, without running, or becoming unequally thick in different places. In the second place, it should become solid within a reasonable time after being applied. Thirdly, the solid should adhere strongly to the surface.

We have seen that lead and zinc paints become solid by the absorption of atmospheric oxygen. But as pure linseed oil also becomes solid by exposure to the air, the drying of the paint is not due to the presence of a dryer, or of the oxide of lead or of zinc. It is true that the dryer acts by increasing the absorptive power of the oil for oxygen gas. The lead and zinc oxides have also drying properties, and we must not neglect the influence of the surfaces that are to be painted. Paint dries at different rates on glass, wood and metal; it dries better on some kinds of wood or of metal than on others, of course under similar conditions of experiment.

Drying on Glass.—Surfaces of glass were coated with linseed oil, also with the oil containing a little white antimony, and with the same compound with the addition of a little litharge. The linseed dried quickly, the antimony compound not so quickly, while in the third compound the presence of the litharge seemed to neutralize the retarding effect of the antimony. The following table shows the results:

	Linseed oil.	Linseed oil and oxide antimony.	Linseed oil and litharge dryer and oxide antimony.
	Days.	Days.	Days.
First coat dried in...	17	26	21
Second coat dried in..	17	8	9
Third coat dried in...	9	9	2
Total	43	43	32

It appears from this table 1. That a glass surface does not allow the paints to solidify so readily as a surface formed of the solid oil or paint. 2. That the antimony oxide is antisiccative, which effect is corrected by the litharge. 3. That in the second coat the glass seems to be still exerting a retarding action on the oil, but this is not so evident in the antimony paint. 4. That the influence of the litharge dryer is evident in reducing the time required for the drying of the third coat. This influence seems to depend not only on the presence of the litharge dryer in the viscid paint, but also on its presence in the solid surface on which the fresh paint is laid.

Drying on Oak.—The influence of the kind of surface employed on the drying of paint is well shown in the case of oak. On oak surfaces stained brown, three coats of linseed oil took forty-six days to dry, oil with a litharge dryer seven days, oil with a manganese dryer still less time. It was also found that linseed oil and white lead and linseed oil and white zinc dried more quickly with a manganese dryer than with a litharge dryer. On a surface of clean oak the first coat of oil took a very long time in drying. On the twenty-second day it was soft and pasty beneath the surface; the oil had sunk into the pores of the wood, and thus prevented it from absorbing the oxygen required for its solidification. This explains why oil dries more quickly on a painted wooden surface than on a porous one. On a porous surface the dryers seem to act with great effect, probably from covering the wood and preventing the oil from sinking into the pores. Their influence is shown in the following table:

	Linseed oil and white zinc.	Linseed oil and litharge dryer and white zinc.	Linseed oil and manganese dryer and white zinc.
	Days.	Days.	Days.
First coat dried in...	66	6	5
Second coat dried in..	6	5	3
Third coat dried in...	6	5	3
Total	78	16	11

This also shows that a surface of linseed and white zinc allows the paint to dry much more rapidly than a surface of porous wood does. A similar effect is produced when the paint is laid on an old surface of paint. The paint itself also becomes more siccative

under the influence of time and atmospheric exposure.

It appears from experiment that paint dries more quickly on poplar than on oak, and more quickly on pine than on poplar. In the experiments on metallic surfaces the most remarkable results were obtained on lead. The first coat of linseed oil dried very quickly on this, as also the first coats of lead paint and of zinc paint. The zinc paint dried first, then the linseed oil, and lastly the lead paint. The zinc paint, however, tended to retard the drying of the subsequent coats. A newly scraped surface of lead acted more energetically than one that had been tarnished by exposure to the air, but the lead covered with one coat lost its influence in hastening the drying of the subsequent coats. The first coat of oil on bright lead was only ten hours in drying. In short, we get this remarkable result, that lead is siccative with reference to pure linseed oil, while white lead itself, a siccative body, is anti-siccative with respect to linseed on metallic lead.

Summary of Results.—The influence of various metallic, vitreous and wooden surfaces is thus summed up by M. Chevreul:

First Coat—*On Copper.*—Oil dried more slowly than both oil and white lead, and oil and white zinc.

On Brass Wire and Zinc.—Oil dried as rapidly as oil and white lead, but more rapidly than oil and white zinc; but on the brass wire the drying was more rapid than on zinc.

On Iron.—Same results as on zinc; but oil and white zinc dried more quickly on iron than on zinc. This is analogous to the fact noticed with lead. The oil and white lead dried more slowly on lead than did the oil and white zinc.

On Porcelain and Glass.—Oil dried a little more quickly than oil and white zinc, and oil and white lead a little more quickly still.

On Plaster.—The oil and white zinc paint dried in about equal times.

On Poplar and Mountain Ash.—Oil dried more slowly than oil and white lead, and also than oil and white zinc.

Three Coatings—*On Copper, Brass Wire, Zinc, Iron, Lead.*—Oil and white lead dried more quickly than oil and white zinc. This was also the case on porcelain, glass, plaster, poplar, and mountain ash. In the case of the woods, linseed oil was found to dry more quickly on ash than on poplar, and more quickly on poplar than on oak.

Effect of Temperature.—Some of these surfaces may, however, be regarded as indifferent, as respects their influence in quickening or retarding the drying of paint; but the temperature and other circumstances modify any general conclusions that may be drawn on the subject. Paint dries more quickly at from 77° to 82° Fah., than from 59° to 64° Fah., other things being equal. This explains why, in practice, the proportion of dryer varies with the temperature. In winter it is customary to add from three to nine, and even ten per cent of dryer to the linseed; in summer not more than half, one and a half, or two per cent, and it may even be left out altogether in the last coat.

Effect of Dryers.—The drying property of linseed oil is nearly always increased by the addition of white lead, and in most cases by that of white zinc. If the compound be not sufficiently siccative, it can be made so by the addition of a dryer, whether of litharge or of manganese, due respect being paid to the varying conditions of the surface, number of the coats, whether first, second or third, temperature of the air, and the amount of natural light present. But the influence of the lead or manganese dryer, as will be gathered from the foregoing details, is not so important as is generally imagined. It can be dispensed with in the second and third coats, and even in the first if the temperature of the air be favorable. Linseed oil by exposure to light and air loses its yellow color and becomes siccative, so that it can be employed alone with white lead or white zinc without detriment to their purity. If white zinc be associated with the sub-carbonate of zinc, the dryer may be dispensed with altogether.

Lustre of Paint.—Paint owes its lustre and smoothness to the oil alone. If oleic acid were mixed with metallic oxides in such proportions as to form solid chemical compounds, and the acid were to pass quickly from the liquid to the solid state, the result would not be a smooth, uniform oleate; but when the drying oil passes slowly into the solid state, in consequence of the gradual absorption of oxygen, and the changes pointed out by Mulder, the very slowness of the process allows the oily molecules to arrange themselves into a symmetrical compound, which would be transparent were it not for the opaque particles of the white lead imprisoned in the compound. If these opaque particles are not in excess, the molecular arrangement is such that the paint dries into

a surface that is lustrous, and even brilliant, in consequence of the mirror-like reflection of the solidified oil.

Effect of Turpentine.—This substance is added by painters, in order to diminish the viscosity of the paint, and to allow it to spread more easily under the brush. If the surface is to be polished, a large proportion of turpentine is used; if it is to be varnished, as much turpentine is added as will render the paint very fluid, but not too fluid to work with; if the paint is to be very durable, and it is to be neither polished nor varnished, only a small proportion of turpentine is to be added. As turpentine dries to a great extent by evaporation, one of its chief uses is to hasten the drying of paint. Thus, three layers of linseed oil on glass dried in twenty-five days; but when about thirty per cent of turpentine was added to the oil, the mixture dried in twenty days. This drying effect is promoted by a previous exposure of the turpentine to the air. When both oil and turpentine have been previously exposed, the drying takes place still more quickly. Exposure to air has a similar influence on the other ingredients of paint, even on the white zinc.

Other Dryers.—This exposure in the case of turpentine favors the combination with atmospheric oxygen and the consequent resinification of the liquid. Exposure in the case of a porous body like white zinc may also lead to the physical absorption of oxygen, and thus hasten the drying. If this physical effect were really obtained in the case of white zinc and white lead, Chevreul thought it likely that the presence of other solid bodies in the paint might have a similar effect. But before putting them into the paint, their influence as surfaces was tested. When linseed oil was laid on white lead, three coats dried in seven days; but on sulphate of zinc they occupied eighteen days in drying, twelve being required for the first coat and two for the second; white lead is therefore more siccative than the zinco-sulphate. In both cases the first coat acted as a dryer to the second. When a mixture of sulphate of lead and white lead was used as the surface, the oil dried almost as quickly as on white lead alone. It has already been shown that the addition of the litharge and manganese dryers made the linseed oil dry more quickly; that is, it became more capable of absorbing oxygen from the air. It is remarkable that this absorptive power is increased by the addition of solid bodies, such as sand. Linseed oil mixed with white lead dries more quickly than the oil alone, so that white lead is a dryer or siccative. Oil mixed with sulphate of lead dries very slowly; but a mixture of oil, sulphate of lead and white lead, dries as quickly as oil mixed with white lead only. Hence the presence of white lead confers extra drying power on sulphate of lead. Carbonate of zinc acts as a dryer, when added to oil or white zinc; and the mixture dries more quickly than oil mixed with white zinc only. Oil mixed with zinc carbonate sets more rapidly than with zinc white; but it forms a semi-transparent, not an opaque paint. As zinc carbonate renders oil and white zinc more siccative, it might be substituted for the manganese dryer, which has the disadvantage of imparting color to zinc white. Two paints were prepared, one consisting of 100 lb. of linseed oil, 75 lb. of zinc white, and 25 lb. of zinc carbonate; the other of 98 lb. of the oil, 2 lb. of the manganese dryer, and 100 lb. of white zinc. With each of these paints a door was painted. Four hours after they had been applied both paints appeared to be equally set; but the surface coated with the first paint was whiter than that coated by the second; the whiter paint was, however, the less adherent.

ECONOMICAL RAILWAYS.

AMERICAN FEATURES — THE NARROW GAUGE — IMPROVED LOCOMOTIVES — WELL FILLED TRAINS.

The interest of the profession and the public, in this subject, is on the increase, especially in England. Although at the first glance the idea of light, cheap railways, seems an approach to the American system, yet upon investigation it will appear that only one or two features of construction and working, that are distinctively American, are advocated for the guidance of English constructors and managers. Let it be always and distinctly understood that the "Light Railway" movement in England is not an indorsement, in any degree, of the American counting-room system of *bad* railways—poor iron, cheap machinery and rough roads. On the contrary, the improvement of locomotives, running gear and permanent way, are among the chief features of the proposed reform.

The features that might be called American, as proposed for new British railways,

especially in the rural and mining districts, are, first, following the surface of the ground —going over and around hills rather than through them—up to certain limits of curvature and gradient, say one in 40 and five chain curves; second, the use of a single track worked by telegraph; third, filling the trains with paying load. In these respects even we might improve. But in the other proposed economies we need as much instruction and reform as the English, viz: in the narrow gauge for branch lines of light traffic, and especially for under-ground city lines, where every additional foot of surface bought, and cutting made, tells largely on the cost; and in a better system of running gear for all lines; in articulated rolling stock, and in the utilization of weight for adhesion.

In a former article* we considered the excessive and unnecessary cost of English lines—a cost made up of parliamentary expenses, land damages, and heavy earthworks and engineering structures, to secure straight, level roads. We now propose to consider some other features in the proposed reform, compiling from the standard authorities before quoted: First, the use of single lines.† These, if worked by telegraph upon the block system would be equally safe, and in all respects as sufficient as double lines. It would be an active traffic that required twenty-four long and well filled trains each way daily, yet this is but one an hour in each direction, so that the rails of every mile of a double line would be unused for about twenty-three hours of the twenty-four. A proper adjustment of trains, proper care, and the indispensable aid of the telegraph, render a single line as safe as a double line, it being understood that the trains are not so numerous as to exceed say two each way in the hour. The extra cost of a second line of way, including extra width of cuttings, embankments, viaducts and tunnels, cost of land and cost of permanent way, cannot be taken as much less on the average of English lines than £5,000 per mile, upon which the interest charge at five per cent is more than 1s. per train mile for eight trains each way daily, these trains easily accommodating a daily traffic each way of 1,000 passengers and from 500 to 1,000 tons of goods. Single lines form the majority of the Prussian railway system, which is worked with fewer accidents than almost any other in the world. The single line system in the United States, when worked by telegraph, has not proved unsafe; the greater number of "accidents" on these roads resulting from bad construction and attendance.

The narrow gauge is advocated by various authorities, among others, Mr. Hulse,* as follows: There are strong reasons for preferring the 3½ft. to the 4ft. 8½ in. system for local railways. The rails of the former do not exceed 40lb. to the yard; tunnels and bridges of a height not exceeding 10½ ft. may be employed; open cuttings of much smaller dimensions; and curves may be used of a radius of only two chains, the locomotive engines need not exceed 15 tons weight; carriages 5 tons weight; and on no driving wheel would there be more than three tons. Whereas on the 4ft. 8½in. system the rails are 80lb. to the yard; tunnels and bridges 24ft. wide, 16ft. high; open cuttings in proportion; curves not less than eight chains radius; locomotive engines, 30 tons weight; carriages, 8 tons; minimum load upon each driving wheel, 6 tons. The short curves admissible on the narrow guage avoid to a great extent the destruction of property, villa residences, etc.; that is in passing by, instead of through them. The minimum radius of the curves and minimum height of headway admissible in each system are the most important features to be considered in deciding upon the best system of railways for towns which have canals, rivers, existing railways, a labyrinth of sewers, gas and water pipes ramifying throughout. Another important feature to be considered, of course, is the question of cost. The 3½ft. system, it is estimated, will cost less than two-thirds as much as the 4ft. 8½ in. system, and may be worked at a correspondingly small expense.

It may be asked why not adopt a 3ft. or even narrower system. The answer is that the 3½ft. system is already largely adopted in Queensland, Ceylon, Norway, Belgium, and other places, and with complete success. In designing the carriages for the local line, the 3½ft. gauge is found to give ample accommodation. The carriage which promises to be most suitable is what may be termed of the omnibus type, with seats arranged on each side and a longitudinal passage, say

* Van Nostrand's Magazine, Vol. I, No. 3, p. 243.
† See also a list in the "Railway Notes," on a following page, of particulars and results of narrow gauge lines.

*Address of Mr. W. W. Hulse, President, before the Manchester Institution of Engineers.

30in. to 36in. wide down the middle, with doors opening inward at the ends. The leading dimensions are 20ft. long, 6ft wide, and 6½ft. high inside. Carriages of this size would accomodate 24 passengers, twelve on a side, and give over 30 cubic feet of space to each. It might indeed be found desirable to adopt even a 2ft. gauge in some districts for cheapness, as has been done in North Wales, where the Festiniog Railway has a gauge of 23in., locomotive engines under 8 tons weight, and over this railway of thirteen miles in length, were carried in 1865, 2,500 passengers, 11,000 tons of general merchandise, and 90,000 tons of minerals, yielding a profit, it has been stated, on the capital outlay of 26 per cent.

Another authority says on this subject: As a rule, we are not favorable to the adoption of narrow, or more properly, small gauge railways; they appear, as it were, to constitute a bar to the future development and extension of commerce and traffic. We would greatly prefer to witness a large and important undertaking, designed and executed upon a scale somewhat exceeding the proportions actually necessary, than to witness it carried out in a manner that barely sufficed to meet the exigencies of the moment. There is a medium between building for posterity—between concerning ourselves about the probable state of our coal fields after the lapse of half a dozen centuries—and constructing works so that they should be, in the main, capable of answering their intended purpose for the next fifty years. To each generation belongs its own duty of construction, reconstruction, demolition and alteration, and it is unjustifiable to incur a heavy extra expense in order that "a thing may last for ever." Are we, then, awaking to the conviction that we have spent millions upon railways in endowing them with properties that are self-destructive? One of the reasons influencing Brunel in his recommendation of the seven feet gauge was, that by thus enlarging the base of the rolling stock, increased stability would be obtained, and a speed ensured higher than that which would be compatible with safety upon a narrower track. Time has shown this reasoning to be fallacious; the trains upon the Great Western do not run faster, or, practically, with greater security than those upon other lines. Similarly, by its own supporters, the 4 ft. 8½ in. gauge was considered the narrowest that could be employed with safety, bearing in mind the great velocity that was expected would be ultimately attained upon it. It is needless to mention that the velocity anticipated never has been attained on either of the gauges. Both Stephenson and Brunel, it is well known, contemplated the probability of running trains at a speed of a hundred miles per hour, whereas the average maximum reached is barely half this amount, and the minimum is something less than what was the usual pace of the old "fast coach." It must not be understood that we consider this conclusion (favoring a narrower gauge) to apply to all our railways. A line similar in extent and importance to the London and North-Western, constructed upon a gauge of three feet or three feet and a half, would be a miserable failure, but a double line upon a similar width of track, to convey the coal traffic from Newcastle to London, might not only present a different appearance, but prove a very remunerative speculation.

We have too long adhered to a false system of locomotive construction. While greatly overloading the driving wheels of our engines, we throw away from one-half to two-thirds of the total adhesion weight. We also make needlessly large driving wheels, often employing 6½ft. to 7½ft. where 5ft. to 6ft. would answer the fair requirements of traffic, and permit of smaller cylinder and less weight of working machinery. We can see no solution of the problem of economical locomotives except in the double bogie system. In these almost any length of total wheel base may be had without straining the way or inducing excessive friction; the weight is equalized on all the wheels and the weight per wheel kept down to 4 or 5 tons, instead of, as is now often the case, 7 or even 8 tons. Fairlie's engines are also rid of the burden of the lumbering tender, a great 12 or 14 ton monstrosity, with the additional weight of, say, a ton of coal, and from 5 to 10 tons of water, water which should be "picked up," in quantities of one or two tons only at a time, as wanted, from Mr. Ramsbottom's troughs. A double bogie tank engine having eight 5ft. wheels, and weighing but 36 tons, the wheels driven by two pairs of 14 in. cylinders, with a stroke of 2ft., would, with a very moderate steam pressure, pull a train of a gross weight of 300 tons up a two mile incline of 1 in 60, at the rate of 20 miles an hour, a work corresponding to nearly 800 horse power, during the six minutes of the run, in thus surmounting an elevation of

more than 175ft. Such engines, without excessive total weight, would have a power sufficient to deal easily with trains of much greater weight than the present, upon gradients and through curves seldom met with on our own old, costly, "first-class" lines.

A farther economy should consist in running fewer, slower, and better filled trains, thus dividing the expenses per train among a greater number of passengers or tons of goods in that train. It was not long since stated that the London & North-Western, Great Northern, Great Western, and Midland Railways together run fifty-two passenger trains daily between London and Manchester! So far as through traffic is concerned, three or four each way daily should serve every reasonable requirement. Railway promoters and engineers must yet awake to the fact that the most profitable and useful railways are those made and worked for the great paying lower class, as distinguished from the far less numerous and far more fastidious upper class. The former do not require either very fast or very frequent trains. An excursion train shows with what they are willing to put up. And a thousand passengers in a train, paying each a farthing a mile, £1-0-10 per train mile, is about the most profitable load an engine can draw, unless it be a bullion train, paying, it may be, £4 or even £6 per mile, as has been the case on the South-Eastern line.

In cases, however, where there is a large and constant stream of passengers, railway carriage can be cheapened enormously, with abundant remuneration to the carrier. We can best illustrate this by contrasting the fares on the Metropolitan Railway with those which are charged and found quite unremunerative upon country branch lines. From Notting-hill to Moorgate-street and back, a distance of twelve miles, first-class passengers are carried for 1s.; second, 9d.; third, 6d.; being at the rates of 1d., and ¾d., and ½d. respectively per mile; yet that line cost an average of over £500,000 a mile to construct. But on a branch country line, the rates may be 3d., 2d., and 1d., a mile, and the cost of the line only £10,000 per mile, yet no remuneration will be obtained.

Land damages are often a most unjust tax upon railways and the public. It should require no parliamentary contest to make a railway more than to make a highway or to open a street. And so far from landowners being "compensated" at extravagant rates, the benefits, generally very great, which railways confer upon their property should be considered and taken into account. The eight acres of land taken for a mile of railway may be worth far less, valuable though it be, than the benefit which the railway itself confers upon the adjacent hundreds of acres. The question arises, are new cheap lines required on routes where the present costly lines exist. The older lines were constructed at immense cost for a speed for which a great majority of the public are unwilling, if not unable, to pay. And it does not answer the question nor the purpose to say that they can have as slow a speed as they choose on the existing lines. So they might; but, unless the great capital charge upon these lines is in part sacrificed, the slow speed will not after all be a cheap speed to the passengers. Unless the companies are prepared to do this—and it is certain that they are not—the public have a good right to call out for free trade in railways. Even a war between competing companies would be for the time to the public benefit, and it is certain that the company having the smaller capital burden would have the advantage in any contest. Its line may have steeper gradients and sharper curves, involving a somewhat greater charge for locomotive power and maintenance of way; but there would not be the long tunnels, the lofty viaducts, the grand metropolitan approaches, and the magnificent termini to pay interest upon.

In conclusion, it is tolerably certain that, with the cheaper lines and more economical mode of working, taken together, nearly one half of the present rates of fare might be saved. Such economy is not without precedent. English "railway men" are mortified to read in our Continental Bradshaw as follows: "The railway system (of Belgium) was adopted as early as 1833, and at the present moment no country in Europe is better provided with railway accommodation than this industrious and prosperous land. There is not one town or village of any importance without its railway communication. The fares are lower than in any other country; for long distances not exceeding ½d. a mile first class, ⅓d. second class, and ¼d. third class—one-fifth of the rate charged in England." Yet the Belgian lines are profitable to the state, and that too, nothwithstanding that all the elements of necessary cost, whether of construction or working, are as great as in England, excepting only the cost of labor, and the salaries

of officials. There is no difference, in principle, between the English and Belgian systems of railway construction, nor in the rolling stock employed.

DIRECT ACTING STEAM PILE DRIVER.

SYSTEM PATENTED BY M. J. CHRETIEN, PARIS.

Translated from "Le Génie Industriel."

In order that pile driving may be effected rapidly and economically, certain conditions must be satisfied, the chief of which we will indicate. Of the first importance is the rapidity of the blows; next to that is the weight of the ram, and lastly the height of the descent. At first, it might seem that with a given fall and weight of ram, the number of blows would be the same, whether struck at long or at short intervals. Practice, however, shows the reverse of this to be true, and it is not difficult to account for the difference in the two cases. For example, it might be necessary under certain circumstances, to give 100 blows at the rate of four or five per minute, in order to sink a pile to a given depth, while it is well known that at the rate of fifteen or twenty blows per minute the amount of drift would be considerably greater; in other words, fewer blows would be required to produce the same result. The difference is such that in certain soils the results might vary in the ratio of one to two. It is easy to see that if a pile, which has received a series of blows, is allowed to remain undisturbed for a sufficient length of time—or possibly only a few minutes—the earth which has been forced aside by the entrance of the wood settles back around it, and ultimately sets. The result of this adhesion is an increased resistance to driving. But if the blows are repeated very rapidly, the earth, which is more and more thoroughly displaced by each successive stroke, has not time to settle back or to adhere. The pile is, as it were, sunk into a hole in the ground, and the work is but little more than that requisite to drive the point. These effects are most decided in soft ground, in sand, and in works under water. Heretofore, in prescribing the weight of the ram and the number of blows, engineers have merely indicated the point at which the pile refuses to sink lower; but in view of what has been said we think they should no longer neglect the time during which the blows should be given.

The weight of the ram is of considerable consequence, but its importance should not be exaggerated, especially when it is possible to regulate the fall and velocity. A heavy ram, falling from a great height, gives a powerful shock, but beyond certain limits the effect produced ceases to be proportional to the weight, and besides, there is the disadvantage of exposing the pile to splintering, which should by all means be avoided. Any weight in excess of 1,000 kil. is injurious rather than useful, and in general it is not advisable to exceed 800 kil.

The height of the fall is the most variable element, and the best driver is the one which will strike both light and heavy blows with rapidity. There is no minimum, since in some cases it is necessary to begin by striking as lightly as possible; but there is a maximum, for no part of the force of the blow should be expended in splintering or even in sensibly altering the wood. A descent of five meters is the greatest which it is well to employ when the blows can be struck rapidly enough.

The pile driver invented by M. Chretien completely satisfies the conditions just laid down. It is constructed upon the general plan which that engineer has already applied to direct acting cranes and lifts. Its simplicity is such that all deterioration is well nigh impossible, and its maintenance is most economical. By comparing it with the direct acting steam-crane just mentioned, or with the steam-hammer, it will be seen that it is practicable to strike very light blows, and also to strike rapid ones up to a blow per second. The rapidity of movement should be limited only by the boiler power, which should be proportioned to the work which it is desirable to accomplish in a given time.

[The most important peculiarities of this machine are, first, the peculiar method of applying the power to the weight. The chain passes from the ram over a grooved roller at the top of the guides; thence downwards around a second grooved roller, situated in a frame attached to the end of the piston-rod; thence upwards again over two more rollers at the top of the guide-frame, and finally is made fast around a windlass within reach of the engineer. Second, the steam cylinder is of great length—equal, in fact, to one-half the extreme rise of the ram—and works nearly vertically. The mechanical principle involved in raising the weight is that of the pul-

ley in its simplest form; the power being applied *between* the two ends of the chain, and the weight being at one end. Hence the rise of the weight will be twice the amount of movement of the piston.]

The workman who manages the driver has only to move a single lever, and each movement of the hand corresponds to a blow.—As fast as the pile sinks he unwinds the chain from the windlass, thus regulating the fall by the depth to which the pile has been driven. At the same instant he lowers at pleasure the wedges which limit the rise of the ram, and all without loss of time.

There are two ways of driving with this machine—first, by not loosening the ram from the hook, in which case the block descends with the grapnel and chain, and strikes lightly and rapidly; second, by long descents, in which case the ram, arriving at the top of the slides, detaches itself, falls, and is raised as soon as the grapnel takes a new hold.

Finally, the same maneuver serves for putting the pile in position (*à la mise en fiche*). Unwinding the chain from the windlass and fastening the grapnel directly to the pile, the mechanic draws it in by a few strokes of the piston and by reversing the windlass.

It was at the works undertaken by the city of Paris near the Pont de l'Alma that this pile driver was first tried. Its success has been so satisfactory that the engineers and contractors who have observed its workings have ordered them.

MODERN ENGINEERING.

It would be difficult to condense Mr. McAlpine's excellent paper on this subject, lately read before the American Institute. The following points, however, are of peculiar interest:

Since 1829, the locomotive has increased from four to 40 tons in weight, and from fourteen to 60 miles per hour in speed. Then grades of 50 feet per mile were the maximum, now those of 440 feet at Mont Cenis and 528 on the Baltimore and Ohio, have been used. Forty years ago Horatio Allen had to mount the foot-board of our first locomotive himself, now 15,000 are daily whirling over 40,000 miles of railways in this country alone.* The Erie Canal, originally built for vessels of 60 tons, has just been enlarged for those of 250 tons, and its increasing traffic already demands an enlargement for vessels of 1,000 tons. Of the traffic of the great West it now carries more than all of the great trunk lines of railway between the St. Lawrence and the Potomac. One canal boat carries more tonnage than a freight train, and the Erie Canal brings daily to tide water more than five times as much tonnage as the New York Central. Its tonnage exceeds that of all the foreign commerce of New York. The materials used in its construction exceed in quantity those required for the 2,000 miles of the Pacific Railway.

The Niagara and Cincinnati wire suspension bridges by Roebling; the Havre de Grace bridge, of wood, by Parker; the Schuylkill bridge of cast iron arches, by Kneass; and the Victoria iron girder by Stephenson, are among the most noted bridges. In submarine works in this country, the most remarkable are the piers of the Potomac and Croton aqueducts, of the Havre de Grace and Harlem bridges, and the founding of the United States Graving Dock, at Brooklyn. The aqueducts and graving dock were founded by means of coffer dams, the Havre de Grace bridge by means of iron caissons, and the piers of the Harlem bridge are composed of large cast iron columns or hollow piles, driven by the newly discovered pneumatic process. A mass of metal of a ton weight was unknown before the Christian era. Now those in cast iron up to 150 tons, in wrought iron to 40 tons, and in steel or bronze to 25 tons, are made in any desired forms, and turned or bored with the most perfect accuracy.

The works of the ancients are often referred to as excelling, in magnitude, accuracy and beauty, those of modern times. This view is in part at least, quite erroneous. Their works were generally for useless purposes, although there are many exceptions, such as their canals, water works, military roads and bridges. The stones in the temple of Baalbec are the largest of any building in the world save one. They range from 1,200 to 1,275 tons. In one at St. Petersburg they are ⅓ larger. The monoliths of Egypt are from 200 to 300 tons, and a few of 700 tons. The obelisk of Luxor, now in Paris, weighs 250 tons. The "goodly stones" of the temple at Jerusalem weighed 350 tons each. The probable method of constructing the great Pyramid of Gizeh, was by means a mound of earth and an inclined causeway; when the structure was completed the earth was removed. This

* It is estimated that there are over 40,000 locomotives in all countries.—*Ed.*

pyramid contained 6,500,000 tons of stone, and the embankments required 50,000,000 tons of earth. All of the masonry of the Erie Canal amounts to but one-third of this, and all of the earth moved for the Pacific Railway amounts to but that used instead of scaffolding for this pyramid. It required the labor of 500,000 men for thirty years, and cost $5,000,000,000. A modern engineer would construct such a work for $100,000,000, and use a tithe of the men. The Coliseum at Rome was but one-third of the size of the London Exhibition building, and but one-sixth of the Paris building. The tonnage of the Ark was 12,000; of the show ships built by Ptolemy somewhat less, and of the Great Eastern 22,500 tons. Some of the modern men-of-war have nearly 9,000 tons displacement, and our passenger ships 3,000 to 5,000 tons. The largest steam engines in the world are those used in draining the Haerlem Mere, with steam cylinders of twelve feet diameter and fifteen feet stroke, driving eight pumps of 63 and 73 inches diameter, and ten feet stroke. These three engines were capable of delivering a volume of water six times as great as that of the Croton. The next largest pumps are those of the Graving Dock at Brooklyn, of one-third of the capacity of those at Haerlem Mere. The steam engines next in size are those of the Bristol and Providence steamers, with cylinders of nine feet two inches diameter and twelve feet stroke. Seven of the most noted modern engineering works to contrast with the seven wonders of the ancient world, are the Thames Tunnel, the Great Eastern steamship, the Atlantic Cable, the Britannia and Niagara bridges, the Erie Canal, modern ordnance, and the Pacific Railway.

Among the great projects of the age are those for building canals, railways, tunnels, bridges and steamers. In canals, we have the project of one around the Falls of Niagara; a re-enlargement of the Erie for vessels of 1,000 tons; the Suez, nearly completed; one across the Alleghanies in Virginia; one through the Nicaragua Lake or Panama, and one from Huron to Ontario. In railways, we have the Pacific on the eve of completion; the Mont Cenis in rapid progress; one across the continent from Rio Janeiro begun, and many others of magnitude. Of bridges, we have those in progress across our great Western rivers; one proposed across the East River at New York of 1,600 feet clear span; two over the Hudson, above and below West Point; another across the Straits of Messina, covering the "Scylla and Charybdis with clear spans of 1,000 meters (two-thirds of a mile) each," and with piers of 700 feet high, half in and half out of the sea, and finally the modern "Pons Asinorum," a bridge project across the Straits of Dover, sixteen miles long, in clear spans of two miles each, with piers of a 1,000 feet depth in the water. This project is said to be favored by Napoleon. In tunnels we have that of Mont Cenis, eight miles, and of the Hoosac, five miles in length, both in rapid progress; one of wrought iron tubes at London, and another at Chicago, almost completed; tunnels proposed under the East and North Rivers at New York, under the Ganges at Calcutta, and under the Straits of Dover.

THE NEW YORK AND BROOKLYN BRIDGE.—The Board of Consulting Engineers, consisting of Horatio Allen, W. J. McAlpine, J. Dutton Steele, Benjamin H. Latrobe, John Serrell, J. P. Kirkwood and J. W. Adams, have finished their conference, after having sat for three days, carefully examining the details of Mr. Roebling's plans. The result, says the "Times," is a full confirmation of them in their application to the proposed East River Bridge.

The span (1600 ft.) the Board considered entirely feasible. As to the piers; on the Brooklyn side there was a substratum of boulders which the current would not act upon or wash away; here a firm foundation would readily be obtained. But on the New York side the foundation would have to be laid upon a quicksand—substantially the same as that met with in excavating the Dry Dock, where not a stone was found in the whole excavation. It is however very hard, being a decomposed rock. The practical question was, will the scour of the river remove it and undermine the pier? A reference to old charts shows that the current has not encroached upon this shore. The pier might be carried down 107 ft. to solid rock, but the Board thought going deeper than the bed of the river, or say 70 ft., unnecessary. In case of future encroachments, a protection of rip-rap work could be put in. The sand will be loaded to 4 tons per square foot. Mr. McAlpine has found that this sand will safely sustain 10 lbs. per square foot. The masonry will be located on a mass of timber 165×100 ft.×20 ft. thick, bolted together so as not to allow settlement in detail. The durability of this timber, below the mud, is beyond question.

IRON AND STEEL NOTES.

REPORT OF THE AMERICAN IRON AND STEEL ASSOCIATION.—The following abstract gives the more important features of this valuable report. It is published in full in the "Iron Age" of February 25.

The estimate of the production of pig iron for 1868, is 1,603,000 tons* as follows:

	Tons.
Anthracite	893,000
Raw coal and coke	340,000
Charcoal	370,000
Total	1,603,000

The product by States was as follows:

Anthracite.

Pennsylvania	671,955
New York	160,681
Other States	60,364
Total	893,000

Raw Coal and Coke.

Pennsylvania	194,000
Ohio	132,000
Other States	14,000
Total	340,000

Charcoal.

New England	30,000
New York	27,400
Pennsylvania	59,600
Maryland	25,000
Ohio	86,000
Michigan	65,000
Other States	77,000
Total	370,000

The estimated value of the pig iron made in the United States last year, at the average price at the principal market for each kind of iron, was $,000,000.

The product of the forges and bloomeries in the country during the past two years was as follows:

	1867. Tons.	1868. Tons.
New England	8,462	7,500
New York	22,634	23,000
New Jersey	5,980	6,200
Pennsylvania	31,747	33,500
Other States	4,250	5,000
Total	73,073	75,200

Estimating the proportion of the above product for 1868, made direct from the ore, at one-half, or 37,600 tons, a proportion found by careful analyses for previous years to be correct, we find that the grand total production of iron from the one in 1868 was 1,640,600 tons.

The product of the rolling mills in 1868 is estimated at 1,105,000 tons, an increase of 63,000 tons over the production of the previous year. This increase was chiefly due to the larger production of rails amounting last year to 506,714 tons against 462,108 tons in 1867.

Of the total domestic production of pig and rolled and hammered iron, as previously stated, the following are the quantity and value shown with reference to the various kinds of products:

	Quantity. Tons of 2000 lbs.	Average value.
Foundry pig	575,000	$22,425,000
Rails	506,714	34,334,148
Boiler and plate	111,462	15,047,370
Nails and spikes	149,000	16,390,000
Bar, rod, band, hoop, &c., axles and other rolled iron	337,824	35,048,850
Hammered iron	22,000	3,960,000
Total	1,702,000	$127,255,368

The total production of steel in 1868, including 8,500 tons made by the Bessemer process, is estimated at 30,000 tons. The capacity of our steel works is amply sufficient for all the requirements of the country. The excellence of American steel, and its adaptability for every purpose to which this material is applied, can no longer be questioned. No reasonable argument, therefore, can be advanced against such additional protection as this interest demands, and which will redound to the advantage of the consumer no less than the producer.

The following are the quantities and values of the various kinds of iron and steel, and manufactures thereof, imported into the United States during the last fiscal year, comprising the twelve months ending June 30, 1868:

	Quantity. Tons of 2000 lbs.	Value.
Pig iron	118,042	$1,810,482
Castings	.....	32,674
Bar iron	66,383	2,906,231
Boiler plate	1,000	73,221
Band, hoop and scroll iron	15,878	672,264
Railroad iron	228,277	4,781,575
Sheet iron	15,821	1,187,644
Old scrap iron	72,908	1,283,269
Anchors, cables and chains of all kinds	4,306	315,183
Steel ingots, bars, sheets and wire	.....	1,705,337
Manufacturing of iron and steel	.....	8,728,955
Total	522,615	$23,496,835

Later figures than the above, however, are obtained by a reference to the reports of the British Board of Trade, that for the eleven months ending November 30th, 1868, having recently come to hand. By it we observe that during that period 93,073 tons of pig iron were exported to this country, a falling off, as compared with the corresponding months of 1867, of 34,910 tons, and exhibiting a slight increase as compared with the importations of 1866. Of bar, angle, bolt and rod 43,388 tons were shipped hither, against 46,171 tons in 1867 and 68,376 tons in 1866.

One of the most prominent features of the iron trade during the past year was the very heavy importation of railroad iron, amounting during the period above named to 278,035 tons, being 101,820 tons, or about 58 per cent over those of 1867, and 169,603 tons, or 156 per cent over those of 1866.

Supposing the quantity shipped to this country in the month of December to equal the average monthly shipments of the previous eleven months, the total quantity for the year would be 303,000 tons, or nearly forty per cent of the whole consumption of the country—a quantity largely exceeding the importations of any year in the history of the country, excepting 1853-54. The total quantity of iron of all kinds exported to this country from Great Britain during the eleven months being 438,305 tons, against 391,526 tons in 1867, and 313,957 tons in 1866. Of steel we imported 16,700 tons, a quantity somewhat less than during either of the two preceding years. Of the whole quantity of iron exported from Great Britain during the eleven months ending November 30th,

* Tons in all cases 2,000 lbs., unless specially stated otherwise.

1868, about 24 per cent was shipped to this country. The percentage of each kind sent hither was as follows: of pig iron, 16 per cent; of bar, angle, bolt and rod, 14 per cent; of railroad iron, 46 per cent; of castings 11¼ per cent; of hoops, sheets and boiler plates, about 12 per cent; other wrought iron, 3 per cent; of steel, 53 per cent.

The value of iron and steel and manufactures thereof, exported from the United States during the last fiscal year was $9,114,740, as follows:

	Manufactured in United States.		Of Foreign Manufacture re-exported.	
	Quan'ty (cwt.)	Value.	Quan'ty (cwt.)	Value.
Pig iron	7,331	$14,022	.....	.....
Castings	5,112	18,815	.....	$1,035
Bar iron	3,580	22,515	746	1,755
Boiler plate	.....	.....	42	201
Band, hoop and scroll iron	.....	.....	20	97
Railroad iron	189	1,304	14,040	20,097
Sheet iron	.....	.....	501	2,022
Anchors, cables & cable chains	.....	.....	31	8,046
Nails and spikes	53,972	371,317	.....	.....
Manufactures of iron and steel	.....	8,521,437	.....	131,987
		$8,949,410		$165,330

THE ELLERSHAUSEN PATENT.—The specification of Francis Ellershausen, of Ellershause, and Augustus E. Stayner, of Halifax, Nova Scotia, and Adolph Guzman, of New York, N. Y., Letters Patent No. 84,053, dated Nov. 77, 1868, for "Improvement in the Manufacture of Iron and Steel," is as follows:

"The nature of our invention relates to the production of iron in a new and useful condition, suitable for the general purposes of the manufacture of iron and steel, and combining the advantages of improved quality and diminished cost. To enable others skilled in the art to make use of our invention in the manufacture of iron and steel, we will proceed to describe our method of operation, and the results attained thereby.

"Our process consists substantially in mixing together cast iron and an oxide or oxides in such manner and in such proportions as to produce a solid (as distinguished from a fluid) mass, one, and either, of them being in a solid condition, and the other of them in a fluid state, by reason of heat applied to it previously to such mixing. We shall, in this specification, describe more particularly our process as applied to the treatment of melted cast iron with solid oxide. We use cast iron, either taken directly from the blast furnace, or remelted; and for the oxidizing agent, iron ore, crushed or pulverized, may be most conveniently employed, although we do not desire to restrict ourselves to the use of any particular oxide. The mixing may be effected in any suitable receptacle or mould, of such dimensions as will give to the resultant mass the desired shape and size. An ingot mould in two pieces, united and held together by bands, will answer the purpose.

"In the bottom of this mould we first place a small quantity of iron ore, so that the mixing may commence as soon as the melted cast iron is introduced. We then pour into the mould a stream of liquid cast iron, and, simultaneously therewith, a stream of finely-crushed or powdered ore, keeping the flow of each as steady as possible, and stirring them constantly with a tool (preferably made of wood), so as to effect an intimate admixture. Care must be taken that there shall be fully enough ore for the operation. It will be found that on this admixture the liquid cast iron instantly becomes pasty, and then solid, so that as the materials are poured in and mingled, a solid (as distinguished from a fluid) mass is built up until the mould is full. Removing the full mould, and supplying a fresh one continuously, the operation is kept up until the whole of the cast iron has been operated on. On opening these moulds, by removing the rings and wedges by which the sections are held together, the mass formed therein is turned out. This mass is a loose, spongy ingot, from which the excess of ore which has not combined with the cast iron will shake out.

"To the material thus formed we have given the name of "pig bloom," if cast in a mould or other such receptacle, and preserved in the shape thus acquired; but if the ingot be broken up small, or if this material be formed in such a manner as to consist of smaller pieces, flakes, granules, plates or scraps, then we call it "pig scrap." This "pig bloom," and "pig scrap," will be found to be mechanical mixtures or conglomerates, consisting of particles or grains of cast iron, of ore, of perfectly converted wrought iron, and of still other particles in various intermediate conditions. But if there have been tolerable skill and care exercised in mixing, the mass will be converted into a condition so nearly akin to that of wrought iron that it will only need the judicious application of heat to resume and complete the chemical operations, which having been commenced in the process of mixing, were arrested by the cooling of the mass, in order to perfect the conversion of the cast iron and the ore into wrought iron, by the combination of the carbon of the carburet with the oxygen of the oxide. In fact, this part of the after treatment is conducted as if the result of the mixing of the ore with the cast iron were already pure wrought iron, because the heating which is given to it during the further working, will supply all the conditions required for actually producing wrought or malleable iron. It will also be found, in practice, that this "pig bloom" and "pig scrap" are capable of enduring, without damage, a very great exposure to heat, both in intensity and duration, and thus the impurities can be sweated out of the metal to an extent which is not possible by the old methods of iron metallurgy, or at least not without great expense.

"The making of the pig bloom, or pig scrap, in the manner described, affords a convenient and very efficient means of obtaining the good effects of such materials as are known to be beneficial, either as detergents or as alloys, in some of the operations of iron metallurgy (as in the crucible), but which have wholly or partially failed to assist in the blast furnace, the refinery, the bloomery, the puddling furnace, or the Bessemer converter. By combining such materials with the pulverized ore, they enter into intimate mechanical admixture with the mass of the pig bloom or pig scrap during the process of "mixing," before described, and being thus imprisoned in the mass, and subjected for a long time to a heat too great for them to endure as solids, they must either escape as fluids or gases, or else become chemically incorporated with the iron.

"Instead of "mixing" by pouring the streams of finely-crushed ore and of fluid cast iron simultaneously into a mould, the same result, substantially, may be reached by scattering the cast iron on the bed of ore, or by delivering it on a moving surface, upon which ore may be placed before or after the metal is deposited; or, indeed, a variety of methods may be devised whereby to bring the fluid cast iron and the solid ore into a contact sufficiently intimate to produce a conglomerate of the character hereinbefore described. The method of operation may also be

varied by employing the oxide or oxides in a melted state, and the cast iron, granulated or otherwise finely divided, in a solid as distinguished from a fluid state, mixing them in such manner as to produce the conglomerate desired.

"Iron ore or oxide of iron, has been described as the oxidizing agent in our process, but we do not confine our invention to the use of that material, as other oxides may be used in combination with or in lieu of it. We are aware that the removing of the carbon of cast iron to a greater or less degree, by means of oxides, is not new, and that the mixture of solid oxides with fluid cast iron is performed in the puddling furnace, and in other operations; but this is done under other conditions, and with different results. But the novelty of our process consists in mixing solid oxides into and among fluid cast iron, or of fluid oxides with solid cast iron, granulated or minutely subdivided, in such a manner and in such quantity as to produce a solid conglomerate of the two substances, and also in effecting this mixture, and producing the resulting pig bloom or pig scrap, without the application of other heat than that of the fused cast iron or oxide, as the case may be, thus dispensing with the use of a furnace for any part of the process of mixing after the melting of the cast iron or oxide, whichever of them is used in a fused condition.

"It will be found that the material thus produced may be used in like manner as any wrought-iron of similar shape, so that when raised to a welding heat, the pig bloom, manufactured as hereinbefore described, may be pressed, squeezed, hammered, rolled, or worked in any of the methods employed in the treatment of wrought iron, and with like results, excepting that the article of wrought iron produced by our process is superior in quality to that obtained in the ordinary way.

"What we claim as our invention, and desire to secure by Letters Patent, is—

"1. As a new article of manufacture, pig bloom, or pig scrap, being a conglomerate of cast iron, oxides, wrought iron, and particles of matter more or less nearly approaching one or other of those substances, produced by admixing, and bringing in contact with fluid cast iron, oxidizing substances in a solid state, in such a manner and in such quantity as to produce a solid condition of the mass.

"2. The mixing of cast iron with an oxidizing agent, one or other of which is rendered fluid by heat applied previously to such mixing.

"3. The production of wrought iron from cast iron, by mixing with the latter, while fluid, a sufficient amount of oxidizing material to produce a solid condition of the mass.

"4. The production of wrought iron from oxides of iron, by mixing the latter with molten cast iron to such an extent as to produce a solid conglomerate of the two.

"5. The employment of detersive agents and useful alloys, by mingling them, or either of them, with the oxides used in the process hereinbefore described, so that they shall become part of the conglomerate, and have such intimate contact and connection with the mass as to produce their proper chemical effects when it is afterwards subjected to the action of heat.

WELDING POWER.—A powder of the following composition, recently patented in Belgium, is said to be very useful for welding iron and steel together. It consists of one thousand parts of iron filings, five hundred parts of borax, fifty parts of balsam of copaiva or other resinous oil, with 75 parts of sal-ammoniac. These ingredients are well mixed together, heated and pulverized. The process of welding is much the same as usual. The surfaces to be welded are powdered with the composition, and then brought to a cherry-red heat, at which the powder melts, when the portions to be united are taken from the fire and joined. If the pieces to be welded are too large to be both introduced at the same time into the forge, one can be first heated with the welding powder to a cherry-red heat, and the others afterwards to a white heat, after which the welding may be effected. Another composition for the same object consists of fifteen parts of borax, two parts of sal-ammoniac and two parts of cyanide of potassium.—These constituents are dissolved in water, and the water itself afterwards evaporated at a low temperature.

ANALYSIS OF BESSEMER STEEL AT THE DIFFERENT STAGES OF THE PROCESS.

	a.	*b.*	*c.*	*d.*	*e.*
Iron:					
Graphite	3.180	.....	.....	.....	.....
Combined carbon	.750	2.465	.909	.087	.234
Silicium	1.960	.443	.112	.028	.033
Phosphorus	.040	.040	.045	.045	.044
Sulphur	.018	trace.	trace.	trace.	trace.
Manganese	3.460	1.645	.429	.113	.139
Copper	.085	.091	.095	.120	.105
Iron	90.507	95.316	98.370	99.607	99.445
Slag:					
Silica	40.95	46.78	51.75	46.75	47.25
Alumina	8.70	4.65	2.98	2.80	3.45
Oxide of iron (Protoxide)	.60	6.78	5.50	16.86	15.43
Protoxide of manganese	2.18	37.	37.90	32.23	31.89
Lime	30.36	2.98	1.76	1.19	1.23
Magnesia	16.32	1.53	.45	.52	.61
Potash	.18	trace.	trace.	traces.	traces
Soda	.14	trace.	trace.	traces.	traces
Sulphur	.34	.03	trace.	traces.	traces
Phosphorus	.01	.04	.02	.01	.01

a. Gray pig (63 Austrian cwt. 83 pounds) and blast furnace slag.

b. After the first period; slag from the converter.

c. After the second period; slag from the converter.

d. At end on turning down; slag from the converter.

e. Finished product after addition of recarbonizer; slag from converter.

First period ceases when long bright flame appears.

Second period ceases, as long bright flame begins to grow darker.—*Kupelwieser, Oest. Zeitschr.*, 1867, *No.* 23.

CHROMIUM IN RAIL HEADS.—The London "Mining Journal" states that an improved metal for the manufacture of rails has been proposed, consisting of iron with an admixture of chrome ore. It has long been known that an alloy of about 40 per cent of iron and 60 per cent of chromium scratches glass almost as deeply as the diamond; and Fremy has stated that an alloy of iron and chromium may be formed by heating in a blast furnace oxide of chromium and metallic iron; it resembles cast iron, and scratches the hardest bodies, even hardened steel. Experiments, says this authority, are now being made at four of the largest rail mills in the United States, in order to test the value of an alloy of chrome ore and manganese, with the iron in the puddling furnace, for hardening rail heads, and with every prospect of a successful result.

TREATMENT OF STEEL PLATES.—The tensile strength of a steel plate, with proper degree of hardness, should give an ultimate strength of 33 to 35 tons per square inch. The denser the metal the more injurious the effect of punching. Steel plates of from 33 to 35 tons per square inch tensile strength, suffer more by punching than iron plates of from 20 to 22 tons per square inch, unless the steel plates are annealed after being punched.

Effect of Annealing the Plates.—The plates which had been punched were annealed, when the tensile strength of plate arose to 35.86 tons per square inch or to its original strength. The mean results obtained of experiments of strength of drilled plates riveted together, and of punched plates annealed and riveted together—plates off of same piece—gave for drilled plates 41.075 tons per square inch, and for the punched 41.24 tons per square inch, showing the punched plate when annealed to be equal to the drilled, if the latter is properly annealed. Plates were 5-16 inch thick, rivets 9-16 inch diameter, $1\frac{7}{8}$ center to center, and double riveted.

Mr. Henry Sharp found the effect of drilling and punching steel plates to be as follows:

Number of test.	Thickness.	Area.	Breaking weight on lever.	Weight per square inch of section when drilled.	Weight per square inch of section when punched.
			tons. cwt.		
1 D....	5-16	0.5437	19 3	35.22	.....
1 P....	5-16	0.55625	14 17	.....	26.690
2 D....	5-16	0.55	20 10	37.27	.....
2 P....	5-16	0.5625	13 5½	.....	23.735
3 D....	5-16	0.5466	19 18	36.40	.....
3 P....	5-16	0.5593	12 12½	.....	22.570

Thus proving that punching deteriorated the tensile strength of steel plates, 5-16 inch thick, to the extent of from 26.4 to 37.8 per cent, as compared with drilling, or on an average of 33 per cent. On examining a section of steel or iron plates which has been punched, it will be found that the metal is more or less hard and brittle around the hole (the thicker and harder the plate, the greater the distance).

Effect of Taper Punching on Steel Plates.—Plate ¼ inch thick, cut in two, one piece, punched with a punch $\frac{7}{8}$ inch diameter, clearance being 1-16 inch hole in die. The other plate was punched with the same punch, but clearance in hole being 3-16, making a taper hole in the plate. The ultimate tensile strength of plates, unannealed after being punched, was for the taper hole 32.527 tons per square inch of net sectional area; for the straight hole 26 tons, being 25 per cent in favor of the taper-punched hole, the fracture of the taper-punched plates being more fibrous than the other.—*Am. Railway Times.*

THE PRODUCTION OF PIG-IRON.—The estimated production of pig-iron in the principal iron making countries of the old world is as follows:—The figures refer to the year 1865, which is the latest date for which complete returns are obtainable. In the United Kingdom 613 furnaces made 4,768,000 tons; France, 430 furnaces, made 1,195,000 tons; United States, 260 furnaces, 1,150,000 tons; Belgium, 52 furnaces, 450,000 tons; Russia, 300,000 tons; Austria. 314,000 tons; Sweden and Norway, 253 furnaces, made 246,000 tons; Italy, 37,500 tons; Spain, 60,000 tons.

HISTORY OF SMELTING WITH RAW BITUMINOUS COAL.—Early in the seventeenth century, mineral coal was introduced as a substitute for charcoal in the manufacture of iron; but, the first experiments with raw coal being unsuccessful, the process of coking or charking was discovered, and for a considerable time held secret. It was still believed, however, that coking not only added expense, but wasted fuel, as modern experiments have abundantly proved; and attempts to use raw coal were not wanting. In 1651, a special act of Parliament granted to one Jeremy Buck a patent "for making iron with stone-coal, pit-coal or sea-coal, *without charking.*" Of the success of his operations we know nothing, but presume they resulted in failure; at least, so far as bituminous coal was concerned. A review of this part of the subject will be found in Webster's reports of English patent cases, under the head of the celebrated Crane case. Crane's patent (Sept., 1836) was for the use of raw stone-coal; and it was disputed on the grounds, among others, that he used bituminous coal also, and that the whole was covered by the ancient patents of Buck and others. This plea opened up an extended historical argument.

All these early experiments were made with cold blast, and they were not sufficiently successful to effect a discontinuance of the use of coke. Indeed, it became a maxim among iron-masters that raw coal decreased the product of iron. But after the year 1831, when the use of the hot blast was made more general, the introduction of raw pit-coal began in earnest.

The foregoing is from the "American Journal of Mining." A letter from Col. Chas. Whittlesey to the same journal says: The first use of raw bituminous coal in a stack furnace is claimed to have occurred in 1845, on the waters of the Shenango, in western Pennsylvania. A furnace built the same year on the Mahoning, another branch of the Beaver, just over the State line, in Ohio, made iron with raw coal; and immediately other works sprang up on both rivers, all using the "block," or Brier Hill coal, and all making an article superior to any coke or anthracite iron in America or England.

THE CELLULAR STRUCTURE OF IRON.—It is stated that a crystalline malleable iron does not show prisms is its fracture, but simply a number of faces of planes crossing the cells at right angles, cutting them off short. The process of rolling iron into plates or sheets does not obliterate these cells, but merely modifies them, as they widen out under the pressure; the thin partitions become laminated, and on the regularity of this lamination the quality of the plate very much depends. The cell system of copper is more perfect than that of iron, a result of the pouring of the copper into molds, but the cells are afterwards altered by the pressure in rolling, &c., but never destroyed. If it were possible to make a section one-millionth part of an inch in thickness these cells would be seen.

THE WILSON FURNACE.—The reported production of E. B. Wilson's puddling furnace is sixteen hundredweight of coal to the ton of puddled bars, running night and day. This shows a great saving over what has been used as a general thing in England, or wherever coal is cheap; but it is not so economical as a double puddling furnace built in the Cold Brook Iron Works, St. John, N. B., by Mr. John Wilson, an English furnace builder. This furnace made 42 tons ten hundredweight of six-inch bars (Scotch pig iron) with 27 tons of coal, half Cumberland and half Pictou, equal to twelve hundredweight and three-quarters to the ton of 2,240 pounds.—*Cor. Scientific American.*

ORDNANCE AND NAVAL NOTES.

BREECH-LOADING SMALL ARMS.—On this subject the "Engineer" says:

The great question of breech-loaders for military purposes seems to have reached its most important point, and already seems to lose a large share of interest accorded to it by the general public. The year 1867 was one of great change; last year was rather one of routine. The Small Arms Committee, at Woolwich, after having, early in the year, adjudicated the premium to Mr. Henry, set about their task of choosing a rifle for permanent use, either by availing themselves of the complete design of some candidate for Government remuneration, or by adapting the chief features of several into one perfect weapon. To perform their task efficiently they would necessarily have to institute a long course of experiments of great value in the aggregate, but of little general interest. Thus their time has been occupied for the year, and we believe we are correct in stating that in all probability their report will be published this month.

The report referred to has now been published. The "Army and Navy Gazette" thus comments upon it:

We understand that at length the report of the select committee on breech-loading firearms has been sent in, and it appears, as stated by us several weeks ago, the arm selected is a combination of the Martini action, modified by the committee themselves, and the Henry barrel. Without ourselves impugning this decision, we must, at the same time, say that, among very competent men, there is great doubt that such a combination will recommend itself either to military men, or those conversant with the adaptation of mechanical principles. We may briefly state a few of the objections to the Martini action. 1. A spiral spring has never been found to work with certainty in any arm yet tried. From its nature it is weakest when the blow is given to the cap; and the more the spring is expanded in the act of striking, the less its force, so that the impact partakes more of the nature of a sharp push than the actual blow necessary to ignite the fulminate in a cup. 2. There is always a certain amount of gas which combines the wax used as lubrication for the ball, and also round the cap itself. It is evident a portion of this is continually finding its way into the interior of the block through the opening in which the piston works, as well as at the slot, where the spiral spring acts on the trigger. This will necessarily tend to clog the spring and weaken its already uncertain action. 3. In intense cold—such as is found in Canada and other parts of the world, where the thermometer is frequently from 50 to 60 degrees below freezing point, and at other times from 90 degrees to 100 degrees above it—the condition of the steel in the spring would be so altered that it would be very liable to snap, and be rendered useless at the very time it might be required to act; and however easy it may appear to replace the spring in a workshop, it is not so in an exposed cold place, amidst falling snow, or in the face of an enemy. 4. The front part of the block is obliged to be made with convex face, and in consequence is tangent, and not parallel to the disc of the cartridge, therefore does not back it up as it should do. The result is that the arm is dangerous from the unsupported cartridges bursting, and the pieces of brass foil, of which the cartridge cases are made, being blown into the face of the soldier firing the arm. We understand that this has been endeavored to be overcome, by adding a spring to the block to force the face of it up to the cartridge, but this, it is held, would only add to the risk of clogging, and eventually render the arm useless until taken to pieces and cleaned by an armorer. 5. In loading the arm, should the trigger by any chance be caught in the dress or accoutrements of the soldier, it would not act. When the block closed the arm would, in all probability, be fired, as the whole force of the spring would be in the cap instead of being held back. 6. The breech-block works on a small pin, and, should this pin be too soft, it would soon wear loose and render the block still more dangerous, by causing it not to support the disc of the cartridge even at the point already named. If too hard, it would be liable to snap under the influences of the weather; the blows given by the constant firing would also alter the nature of the iron, by causing it to return to its crystalline state. 7. Extracting the empty cartridge case is effected in this arm by giving a smart pull forward to the trigger-guard when opening the breech. If at any time the pull is not sharp enough, the cartridge case sticks half way, and cannot be got out of the chamber without using the ramrod, and, on the other hand, should the pull be too hard, the empty case is apt to be sent into the face of the soldier firing, or that of his rear rank man. 8. The stock of this rifle is in two parts, which must weaken and unfit it for the rough usage of actual service. On the whole, we are assured that this arm is no improvement on the Peabody rifle, which has already been rejected. Nay, inasmuch as it has the manifest disadvantages of the spiral spring action, the latter weapon is held to be superior, and it is maintained that a rifle, on a bolt principle, will be found, for a military weapon, more safe, simple and effective, conclusions which have been arrived at by two of the greatest and most scientific nations on the continent—France and Prussia. There can be no doubt that the Henry barrel is a most accurate one, but whether it is well adapted for the rough usage of a military arm is a moot point.

In Prussia, says the "Journal Official," the results of a comparative trial which took place in the School of Musketry, at Spandau, amongst the breech-loaders adopted by the different armies, were, according to the official report, the following: The Prussian needle gun can fire 12 shots a minute, the Chassepot 11, the Snider 10, the Remington (Denmark) 14, the Peabody (Switzerland) 13, the Wœnzi (Austria) 10, the Werndi (same State) 12, and the Winchester repeating rifle (United States) 19.

In France the failure of the Chassepot and needle guns is announced. A correspondent of the "Army and Navy Gazette" says: The French and the Prussian Governments, after repeated experiments, carried on at a great cost, have arrived at this conclusion, and admit the fact—that the Chassepot and the needle gun (both on the spiral-spring principle) are useless for the central-fire cartridges, which they have now determined to adopt. Another authority informs us that the French Government have ceased to manufacture the Chassepot, and taken to the Remington instead. The Remington—the only rifle, by the way, which Prussian military men think superior to the Zündnadel—has been likewise introduced into the Danish and Swedish services.

AMERICAN RIFLES ABROAD.—During the past year, Messrs. Remington & Sons, of Ilion, N. Y., have made 86,000 of the "Remington" breech-loaders of various styles, to fill foreign orders, and are now engaged in the manufacture of 40,000 "Berdan" breech-blocks for a Spanish contractor, to be used for the conversion of old muzzle-loaders, or to be applied to new guns, in Spain. We learn by a letter from Paris, written by one who ought to know, that orders are expected shortly from various European governments for about a million and a half of breech-loaders, and five hundred millions of cartridges. The greater portion of these orders will doubtless come to this country, and Messrs. Remington will undoubtedly receive a large share.

WAR ROCKETS.—At a recent meeting of the Manchester Literary and Philosophical Society, a paper was read on war rockets by Mr. J. Nasmyth, C. E. Mr. Nasmyth observed: It may be well to allude to the means that have been employed in the endeavor to secure to war rockets rifle action or precision of flight. These consist in placing the rocket in a V-shaped trough, by which the direction and inclination of the rocket is suitably secured previous to commencing its flight, and so far holding the rocket fair in the direction of the object aimed at. Besides this, an endeavor is made to give the rocket axial rotation during its flight by causing the propulsive gases, while issuing at the rear of the rocket, to rush through skew holes. This latter arrangement does, to a certain extent, give to the rocket axial rotation. But, as axial rotation given by such means does not come into effective operation until the rocket has proceeded a long way on its course, it comes into action too late to have any influence in securing precision of flight. In order, then, to effect our object, I place the rocket inside a tube, into which it slides freely; to this tube, which serves to secure the aim of the rocket, I give, by mechanical means, an axial rotation of some thousands of revolutions per minute, which is transmitted to the rocket then resting within it. The rocket, while thus revolving on its axis at the high velocity above named, is then fired, and so rushes forth from its guide tube impressed with all the conditions of a perfect rifle projectile, and, as such, with every condition present that can secure its reaching the object aimed at. The mechanical means and arrangements by which I propose to effect the object in question consist of a suitable iron stand, supporting the rocket and its guide tube, the latter resting on loose friction wheels, which, while preserving with the utmost exactness the direction of the axis of the guide tube and rocket, permits the guide tube and rocket to revolve on its axis with all due facility. The requisite amount of axial rotation is conveyed to the guide tube, and thence to the rocket resting within it, by means of a powerful clock spring transmitting its rotation to the rocket through a train of wheels. Previous to firing the rocket the second of this train of wheels is locked by a catch or trigger; the string is then wound up, and the aim and elevation of the rocket adjusted. The match of the rocket is then lighted, and in order to secure energetic combustion of the rocket ere it is allowed to rush forth on its course, the rocket is held in check by three slight springs within the guide tube at the rear of the rocket, by means of which it is not permitted to rush forth until the proper energy of discharge of propulsive gases has been acquired. As soon as this is the case the rocket frees itself and then rushes forth impressed with and possessing every condition of a true rifle projectile, combined with all those important properties which rockets possess as implements of war.

FAILURE OF LARGE BREECH-LOADING CANNON.*—Says the "Army and Navy Gazette": There are serious rumors abroad respecting the new marine artillery. Somewhat more than a year ago France arrived at a different conclusion to that of most other nations, and "went in" for large breech-loaders, with which she immediately armed her fleet. The breech would be difficult of description; suffice it to say that it is unlocked and removed on a movable platform. In a great many instances this apparatus has broken down during practice, and several guns have been altogether condemned. The strain of heavy charges has proved too severe a test on the mechanism, which gets out of order, and renders the piece difficult to be loaded or entirely useless.

* See "Ordnance and Armor," pages 580 and 608, for description of these guns, and predicted failure of large breech-loaders.

As to the Armstrong guns, the "Army and Navy Journal" says: The English War Department, after spending millions of money on the Armstrong breech-loading-wrought-iron-coil-rifled gun, knighting its inventor, and growing almost wild over their toy, have now finally abandoned the last vestige of the Armstrong system. It may, therefore, be stowed away among the relics of the past. Some patriotic loyal Americans, it will be remembered, took the Armstrong infection, and subscribed a handsome sum of money to present a battery of these guns to us, in the early part of the war. They seemed to be grieved that we had to trust to our simple smooth-bore muzzle-loaders, when such a triumph of artillery-making was in existence. And some of our (present) English friends and admirals subscribed even more liberally to furnish the rebels with a lot of these guns, and others got into the Southern forts in various ways, so that they used to turn up every now and then when we took a Confederate stronghold. And yet, alas! their course is even now run! The British War Office has issued an order, intimating its purpose to withdraw all the breech-loading rifled guns and substitute muzzle-loaders. We learn from "Engineering" that the Ordnance Select Committee, at the request of the superintendent of the Royal Gun Factories, had been called upon by the War Department to decide on the peculiar construction upon which the 12-pounder, 9-pounder and 7-pounder rifled muzzle-loading guns, estimated for 1868–'69, are to be manufactured. They replied, subject to the Secretary of State for War's approval, that the 12-pounder and 9-pounder guns should be made in accordance with the tracings already approved to guide the manufacture of the experimental 12-pounder muzzle-loading gun, recently tried at Shoeburyness, with a view to the determination of the elements of rifling for these guns, as well as of the 12-pounder and 9-pounder experimental guns ordered for trial on board Her Majesty's ship Excellent.

EUROPEAN IRON-CLAD FLEETS.—The North German iron-clad fleet consists of five ships, viz: two cupola ships with 3 guns, two ships mounting 16 and one mounting 24 guns. All the guns are rifled breech-loaders of Prussian construction. Four of the ships are of iron. The King William, the largest of the five, has a tonnage of 5,939 and engines of 1,150 nominal horse power. The thickness of the plates used for these vessels varies from 4½ to 8 inches.

"Les Luttes de l'Autriche en 1866," lately published, states that the Austrian sea-going iron-clad fleet consists of two frigates of the first class, three of the second, and two of the third. They carry an aggregate of 213 guns and 2,592 men. There is also an iron-clad battery of position, with an armament of sixteen guns and a crew of 229 men. The same publication gives the strength of the Italian iron-clad fleet at four frigates of 36 guns, four of 26, and three of 22 guns each, one ram with 2 guns, two corvettes of 20 guns, two sloops of 4 guns, and two batteries of 12 guns each—in all eighteen vessels, with an armament of 388 guns and an equipment of 7,358 men.

KRUPP'S 11-INCH GUN.—The 11-inch steel gun made by Krupp for the Russian Government, is the largest breech-loader that has ever stood a practical test. The gun weighs 26 tons, and has no preponderance. The rifling is 36 grooves of 770 and 788 in. pitch, 0.135 in. deep, and 0.64 (muzzle) to 0.79 (chamber) wide. The projectile weighs 495 lb.; the charge 82½ lb., giving an initial velocity of 1,360 ft. per second. The number of test rounds was 400, with substantially the above charges. The Prussian and the Belgian Governments have lately ordered a large number of Krupp's 9-inch guns.

THE GOVERNMENT AND INVENTORS.—The following circular, issued by the British Government, will be specially interesting in view of the current investigations, reports and general excitement on the subject among inventors interested in improving war material:

"In consequence of the numerous claims for compensation for loss of time and for expenses incurred by private individuals in working out inventions of various kinds, as well as for rewards in consequence of such inventions, the Secretary of State considers it necessary to make known the following regulations:

"1. Persons who desire to submit any invention for consideration should do so by letter, addressed to the Under Secretary of State. The letter should describe the invention, and state whether the person who offers it for consideration desires to make any claim to remuneration in connection with it. In the absence of such a statement it will be assumed that no such remuneration is expected.

"2. Expenses incurred before the submission of an invention will not be considered to give a claim for repayment. No liability on behalf of the public will be recognized on account of loss of time, or expenses incurred in connection with an invention after such submission, unless authority for such expenses has been previously given by letter signed by one of the Under Secretaries of State; and the liability will be strictly confined to the limits of expenditure authorized in such letter.

"3. All claims for reward will be examined by a council to be held at the War Office, and if any reward be recommended by the council and approved by the Secretary of State, the sum will, with the concurrence of the Treasury, be included in the estimates, together with the report of the council; but it will not be regarded as due or be paid to the claimant until after the vote is passed by the House of Commons.

"4. No claim for reward will be held to be established unless the invention has been adopted into the service or substantial benefit to the public has resulted from it."

THE ARMIES OF EUROPE.—The following statement of the nominal strength of the armies of Continental Europe was not long since given by Baron Kuhn, in the Austro-Hungarian Parliament:

France.	
Army	800,000
Mobile National Guard....	550,000
Total.....	1,350,000

North German Bund.	
Standing army	843,394
Landwehr	185,552
Total.....	1,028,946

South Germany.	
Standing army	156,760
Landwehr	43,411
Total.....	200,171

North and South Germany together.	
Total.....	1,229,117

Austro-Hungarian Monarchy.	
Regular forces, inclu'g navy & reserves ..	800,000
Border troops .	53,000
Landwehr	200,000
Total.....	1,053,000

Russia.	
Field army, including army of the Caucasus.....	827,350
Local forces ..	410,427
Irregulars	229,223
Total.....	1,467,000

Italy.	
Army.....	348,461
Mobile National Guard, including Venetia.....	132,300
Total.....	480,461

THE MONCRIEFF SYSTEM.—We are glad to be able to announce that the Moncrieff contrivance for mounting heavy artillery has been definitively accepted by the Government. Hitherto, as our readers are aware, a 6½-ton gun is the heaviest which has been mounted on this system; but if it is to be really useful, it will have to be employed with much heavier ordnance, and steps are to be taken at once to apply it to a 12-ton gun, as a step towards its further development. Captain Moncrieff has been treated with a prompt liberality. He is to receive, first, a sum of money sufficient to cover the cost of his models and his preliminary expenses. Secondly, he is to receive payment for the time that he has devoted exclusively to the public service (about two years, we believe), at the rate of £1,000 per annum, which rate of pay is to continue so long as Captain Moncrieff is engaged in rendering assistance in making and completing designs for the application of his system, and in superintending the construction of his carriages. Thirdly, he is to receive £15,000 as a reward for the invention, and for the use which may be made of it in Her Majesty's service, either afloat or ashore, in any modification or combination. Captain Moncrieff on his part is required to undertake to communicate fully and unreservedly all improvements which he may deem practicable; in fact, to give the benefit of his knowledge of this particular subject to the country. Of the sum of £15,000, £10,000 is to be paid at once, the remaining £5,000 when the inventor ceases to draw his salary of £1,000 a year. These terms, we say, are liberal, and no doubt they will so be generally regarded; but they are not excessive.—*Engineering.*

THE PALMER SHELL.—A series of trials with a new shell, designed by Mr. Palmer, have recently been commenced at Shoeburyness. The shell is formed with a solid head and a base plate, the intermediate body being built up of a series of rings with serrated edge, which fit closely one upon the other, and together form a short cylinder; a through bolt, tapped at each end, passes through the solid head and the body of the shell, and is bolted to the base, holding the whole together. At the upper end, channels are cut in this bolt, to receive the fuze and communicate the fire to the bursting charge. The upper end of the through bolt is not flush with the point of the shell, but is recessed sufficiently to allow of the introduction of the fuze, which therefore abuts upon the top of the bolt, and cannot be driven into the shell at the moment of impact, as happens at present in the service shell. Two forms of shells were supplied by Mr. Palmer for the first trials at Shoeburyness, the one having a conical, the other a hemispherical head. The bursting charge was introduced through a hole in the bottom plate, which was afterwards closed with a gun-metal plug; the shells were fired from a 64-pounder rifled muzzle-loading gun, with the service charge of 8 lb.

TEN-INCH ARMOR PLATES.—The 10-inch rolled armor plates for protecting the four 22-ton 600-pounders which will be mounted in the two turrets of the iron-clad armored turret ship Monarch, 7,510 tons, 1,100 horse power, have arrived at Chatham dockyard from Sheffield. The plates are the largest ever yet operated upon at Chatham dockyard, each being 19 ft. in length, and weighing rather more than 12 tons. The process of bending the plates has been carried out by means of Westwood and Baillie's powerful hydraulic plate-bending machines, each plate having been bent to the arc of the circle it is to occupy on the turrets without giving signs of the slightest flaw. The plates will lose about two tons each while in the factory, the space occupied by the turret gun ports being cut from each.

RAILWAY NOTES.

NOTES ON CHEAP RAILWAYS.—The following observations, by M. Desmonsseaux de Gioré, C. E., on this important subject, from the "Correspondant," will be of interest to many of our readers at the present moment:

A railway is determined by two elements, which are, to a certain extent, independent of each other, namely, the weight of rails and the gauge: the weight of rails determines that of the engines; the gauge determines (according to the usual speed of traffic) the radius of the curves. On the principal lines of England and the Continent, the rails weigh about 36 kilogrammes per meter (72¼ lb. per yard), and bear engines weighing 12 to 13 tons per axle; the gauge is about 1.50 meters (nearly 5 ft.), the radius of the curves being limited consequently to 500 meters (25 chains) on lines of rapid traffic, and to 300 meters (330 yards) on branch lines. The average cost of these lines is from 200,000 to 500,000 francs per kilometer, *i. e.*:

	Per kilometer.	Per mile.
For the great English lines,	545,000 fr.	£35,000
" French	305,686	19,647
" Belgian	230,000	15,000

In authorizing the construction of local interest lines, the French Administration has usually stipulated (at least as a condition of the State or department subsidy) that the great lines should have power to run their carriages over them; this clause has made the gauge of 1.50 m. compulsory, together with a minimum weight of rail of 18 kilos. per meter (36¼ lb. per yard); but it soon became necessary to raise this weight to 25 kilos. (50¼ lb. per yard) in order to adopt sufficiently powerful engines. The gauge being 1.50 m., it was necessary to limit the radius of curves to 300 meters, so as to avoid an excessive resistance. To such conditions, the cost per kilometer is usually between 100,000 and 110,000 francs (£6,440 per mile). It can be reduced, but not with safety, to 60,000 francs (£3,900 per mile). A frequent cause of excessive prices is the common prejudice against gradients, to reduce which expensive viaducts and works are incurred. But if engineers adopt steep gradients, and especially if they avoid joining the new lines with the old ones, they can reduce indefinitely the gauge and width of rails, and, consequently, the price per kilometer. For instance:

1. The railway from Breelthal (Prussia): gauge, 0.78 meters (2¼ ft.); weight of rails, 10¼ kilos. per meter (21 lb. per yard); cost, 23,000 francs, including rolling stock; the radius of curves is 38 meters (41¼ yards); the line is 20 kilometers (12¼ miles) long; it occupies one side of the carriage road; the engines, loaded, and ready to start, 12 tons, with 6 wheels.

2. Railway of the sugar works (beetroot) at Tavaux-Pontséricourt, in the department of Aisne: two railways; gauge, 1 meter (3 ft. 3⅜ in.); width of rail, 13 kilos. per meter (26¼ lb. per yard); cost, 28,000 francs (£1,800 per mile), including all stock. Engines on four wheels weigh 7¼ tons, loaded; radius of curves, 30 and 40 meters (33 and 44 yards). The ground is very rugged; the section shows frequent gradients of 0.015 to 0.025, then long gradients of 0.050 and 0.060, and even one of 0.075; on a length of 300 meters (330 yards.) Messrs. Molinos and Prosnier, engineers of the line, and managers of the sugar works, might, but for the exceptional natural difficulties, have reduced the cost to 20,000 francs (£1,300 per mile). These lines are made on the side (*accotement*) of the vicinal roads. The legal formalities by which the necessary powers were obtained were very simple, the "communes" consenting to abandon to the company a strip of land of 1 meter in width on the side of the road, with power to add 1 meter to it. The two railways of Tavaux-Pontséricourt traverse two villages, without causing any inconvenience to the inhabitants. The legal formalities and construction were all completed for the greater part of the lines in six months.

The following cheap railways are described by Messrs. Flachat and Goschler, in their Exhibition reports:

3. Four Norwegian railways: gauge, 1.07 meters (3 ft. 6 in.); weight of rail, 20 to 22 kilos. (43 to 48 lb. per yard); weight of engines (four wheels) loaded, 17 tons; total length of lines, 300 kilometers (186 miles.)

4. Commentry and Monttucon line: gauge, 1 meter (3 ft. 3⅜ in).

5. Antwerp and Gand line: gauge, 1.15 meters (3 ft. 9¼ in.). 16 trains run daily on this line at a speed of from 40 to 60 kilometers (25 to 36 miles per hour). In 1865, nearly 500,000 passengers were conveyed on it.

6. Mondalazac Railway, established by the Orleans Railway Company: gauge, 0.75(2 ft. 5 in.); weight of rail, 16¼ kilos. per meter (33¾ lb. per yard); radius of curves, 40 meters (44 yards); weight of engines (four wheels), loaded, 9 tons.

7. Festiniog Railway, near Caernarvon: gauge, 0.61; weight of rail, 15 kilos.; length, 21 kilometers; gradients, 0.0167; radius of curves, 40 meters; weight of engines, loaded, 7½ tons; speed of trains, 16 kilometers per hour. From 1862 to 1863, this line was worked by horses. By using locomotive engines, the working expenses have been reduced 22 per cent.

This line is completely described in the "Engineer" journal.

8. Line built by Mr. Ramsbottom, C. E., at the Crewe Works of the North Western Railway: gauge, 0.46 meters (1 ft. 7 in.); radius of curves, 4 meters (4½ yards); speed of train, 10 kilometers (6¼ miles per hour); weight of engines (4 wheels), 1¼ ton. A similar railway on the *accotement* of a road would certainly not cost 15,000 francs per kilometer (£1,000 per mile).

9. The Mont Cenis Railway, with central rail, invented formerly by M. Séguier, and re-invented by Mr. Fell: gauge, 1.10 meters (3¼ ft.); gradients, 0.045.

Among the broad gauge* railways, the cheapest are:

1. In Scotland, according to a Swiss engineer, Mr. Bergeron, ten cheap railways, length from 10 to 30 kilometers (6 to 18 miles); cost, including rolling stock, from 73,000 to 145,000 francs (£4,700 to £9,400 per mile). Established ten years ago; others have probably been added since.

2. Vitré and Fougères Railway, 36 kilometers (22¼ miles) in length; constructed by M. Debauge, at the rate of 67,500 francs (£4,400 per mile), including all stock. If the directors had not had the

*There is only one gauge in the original railway system of France, namely, 1.44 meters (5 ft. 8⅓ in.). This is called broad as compared to those described above, but is very different from what we call the broad gauge.

unfortunate idea of connecting this line with the "Ouest," they could have reduced the expenditure to 56,000 francs (£3,600) per mile.

The above instances are sufficient to show the absurdity of constructing, as French companies are doing now, unproductive railways at a cost of 400,000 francs per kilometer (£26,750 per mile).—*Railway News.*

EXTENT OF OUR RAILWAYS — CONSUMPTION OF RAILS.—The following statistics are from the late able and interesting report of Henry McAllister, Jr., Secretary of the American Iron and Steel Association:

	Miles.
The number of miles of railroad (including second track, sidings, &c.) in use December 31st, 1868	52,550
Total increase for 10 years ending December 31st, 1868	16,536
Total increase for last 5 years	9,448
Average annual increase for the last 10 years	1,654
Average number of miles in use for 10 years ending December 31st, 1868	43,123
	Tons.
Iron required in laying 43,123 miles averaged at 90 tons per mile, 3,781,070 tons, which at 6¾ per cent for average annual wear, gives iron required for renewal of track	259,948
Iron required for last 10 years for renewing track	2,599,480
Iron required for last 10 years for new track, 16,536 miles, averaged at 96 tons per mile	1,587,456
Total consumption of railroad iron for last 10 years	4,186,936
Iron rails imported for 10 years ending June 30, 1868	1,015,685
Quantity of rails manufactured in the United States during the last 10 years.	3,171,251
Average quantity of rails imported per annum for last 10 years	101,568
Average domestic production per annum for last 10 years	317,125
Total average annual consumption for last 10 years. (About 62 per cent of the consumption of rails is required for renewals and 38 per cent for new track)	318,693
Importation of rails for year ending June 30th, 1868	228,277
Production of American mills for year ending December 31st, 1868	506,714
Increase of importations on average of 10 years	126,709
Increase of domestic production on average of 10 years	189,589
Net increase of consumption in 1868, upon annual average of last 10 years.	316,298

It seems to be the impression, particularly among those whose observations do not extend beyond our great trunk lines, that the percentage of rails worn out during each year is much greater than that given above, but this cannot be the case unless all the estimates that have been made of the number of miles of railroad in the country have been greatly exaggerated. It must be remembered that whilst many of the rails on main lines near our great railroad centers are worn out in a single year, there are thousands of miles of track in the Southern States and in the thinly settled portions of other sections that last over twenty years. In England, the actual waste of iron rails by grinding, oxidation and loss, is said to amount to 20,000 tons a year, while about 250,000 tons require to be taken up and re-rolled. As the number of miles of road there, including second track and sidings, may be safely put down at 23,000, it follows that the average wear and tear of track amounts to 10.36 per cent per annum. Even in that country, where the destruction of track is so much greater than here, we are told that on some lines of light traffic, rails frequently last twenty years, while on lines near London which are under constant and heavy work, many miles of track require re-laying in less than twelve months.

BRITISH RAILWAY ACCIDENTS.—In the year 1867 the railway companies of the United Kingdom paid £347,379 as compensation for personal injury, 209 persons having been killed, and 795 persons injured; nineteen passengers were killed, and 689 injured from causes beyond their control, and seventeen were killed and eight injured through their own misconduct or want of caution. Fifteen servants of railway companies or of contractors were killed, and 62 injured from causes beyond their control, and 90 were killed and 28 injured through their own misconduct or want of caution; ten persons were killed and two injured at level crossings; 57 trespassers were killed (six were suicides), and five injured. In the six years 1862–67 the railway companies paid £1,460,568 as compensation for personal injury done upon the railroads. In those six years 1,268 persons were killed upon the railways, and 4,426 injured; and among them were 112 passengers killed and 3,897 injured without any fault of their own, and 97 passengers killed and 29 injured owing to their own misconduct or want of caution. The risk of life in railway traveling may be expressed thus: In the year 1867 one in about eight and a half million passengers was killed—namely, one in every sixteen millions from causes beyond his control, and one in about every eighteen millions from his own misconduct or want of caution.

NEW IRON RAILWAY BRIDGE IN ITALY.—MM Cail & Co. have contracted with the Upper Italy Railway Company for an iron girder bridge to be erected over the Po at Pontelagoscuro. The length of the bridge will be about 1,400 ft., with four spans of 247 ft. and two of 206 ft. It will be a single line, and supported by two lateral double lattice continuous girders, distant 15 ft. The piers and abutments will be sunk with iron caissons and compressed air. The weight of the superstructure will be 1,267 tons, and the price £24 per ton. Besides that, the price of each pier will be £4,720. There have been for this contract six competitors, all very large firms of France or Belgium.

ECONOMY OF RAILWAY TRANSPORTATION.—On a common road, wheat would consume its own value if carried 350 miles, while by rail it can be carried 3,000 miles at a profit. Railroads multiply by 10 the distance from any grain market at which its wheat may be raised. The same remarks apply to other productions, such as ores.

RAILWAYS IN CANADA.—After some years of inaction the minds of the Canadian people seem to be again undergoing agitation on the subject of railways. We have several times in this journal made reference to the proposed narrow-gauge lines, and it appears that the promoters of them are working energetically to accomplish their ends; it is sincerely to be hoped, however, that before they come to actual construction they will reconsider the whole matter and determine to adopt the gauge of the country. A Canadian correspondent writes to us concerning these lines as follows:

"One thing they are doing, however, which cannot fail to produce a healthy feeling in the public mind, and to convince people here that if they wish for railway accommodation, themselves must lead the way. The promoters of the narrow-gauge lines are thoroughly canvassing every municipality interested for aid by bonuses to their several projects, and they are meeting with a large measure of success. The principles they are endeavoring to instil into the minds of the people may be briefly stated as under: That the lines will be a vast and immediate service to the districts they pass through and will accommodate; that the country is too sparsely populated to warrant the assumption that they would pay in themselves as a commercial investment; that to insure the construction, at least one-third of their estimated cost should be a free gift from the municipalities; that they believe and hope one-third more can be raised in stock, and, if so, that no difficulty should be experienced in raising the remaining one-third, in the debenture bonds of the road. Whether they are right in the last impression or not, it is not for me to say, as they have issued no prospectus nor given the outside public any means of judging what their prospects of traffic are.

"The Port Whitby and Port Perry Railway scheme was chartered at the same time as the two narrow-gauge railway projects, but the directors of this line have wisely eschewed the error of departing from the established gauge of the country. This road will be about twenty miles in length, its southern terminus in Port Whitby on Lake Ontario, and its northern terminus in Port Perry on Lake Scugog; it lies wholly within the county of Ontario, and for its entire length will be of the utmost value as a thoroughfare for that important county, and will realize a considerable amount in local and thorough traffic. But the staple trade of the line will consist in its traffic in sawn lumber, Lake Scugog, with Port Perry at its head, forming a collecting depot for a vast chain of inland lakes and rivers, whose shores abound in pine timber of a very valuable description. It is estimated that this vast lumbering district will for a long series of years yield large supplies of timber for the American markets, while the lakes and rivers alluded to afford water conveyance of the cheapest character to the northern terminus of this railway, while the railway itself affords the shortest "portage" to Lake Ontario from whence the lumber will be distributed to the various markets in the United States. Already the directors have had written contracts offered them for freight amounting to forty millions of feet, board measure, of sawn lumber annually; while in the prospect of the road being built numerous sawmills are now being erected, depending on this railway as an outlet for their manufactures."—*Engineering.*

COST OF BRITISH RAILWAYS.—Ten years ago, the Brighton Company's system was 180 miles in length, and had cost eight and one-third millions, or £46,250 per mile. Since then the mileage has doubled, being now 365 miles, and the capital has more than doubled, standing now at about twenty millions. No less that five and a half millions of capital were raised between 1862 and 1866, and this without increasing the gross receipts by more than about 15 per cent. Yet as long ago as 1854, with but £7,690,000 of capital raised, the gross receipts were upwards of £685,000, whereas in 1866, with twice and half the capital, they had increased to but £1,190,000, or by but little more than one-half. The whole system of 365 miles has now cost nearly £55,000 per mile, on the average of the main line, extensions, and branches.

It will not be long after the meeting of Parliament, before it will be shown beyond disproof—although, of course, not beyond dispute—that a new main line can be made to Brighton at a total cost, including land (the latter alone taken at about £14,000 per mile), of only £35,000 per mile, and it can be as clearly shown that the first class fare between London and Brighton need not—and if an Act be obtained fixing the fare shall not—exceed 6*s.* for the 50 miles.—*Engineering.*

BUSINESS OF THE WORLD'S RAILWAYS.—According to the calculations made by the Government Statistical-Office at Berlin, the number of passengers conveyed daily by the railways of the world amounts to three millions, and the quantity of goods to twenty-seven millions of centners, or a million and a half of tons. Also 58,000 telegrams are forwarded, and four millions of letters delivered every day. The daily gross receipts of the railways are 8,000,000 florins; they possess 40,000 locomotives, 1,200,000 carriages and vans, and give regular employment to a million persons. The aggregate length of the telegraph wires would, if united, reach to the moon and back again.

ENGLISH RAILWAY CARRIAGES.—The long eight-wheel carriages of the Metropolitan railway weigh, with their gas apparatus, about sixteen tons, empty. The first class carriages seat 56 passengers; the third class, 80. A few four-wheel carriages are now being made of half the length and capacity, to weigh about seven tons each.—There will be a moderate saving of weight, but at the sacrifice, perhaps, of some degree of steadiness.

BELGIAN RAILWAYS.—In eight years the charges on goods on the Belgian State railways have been lowered on an average 28 per cent; the public have despatched 2,706,000 additional tons of goods, they have economized upwards of £800,000 on the cost of carriage, and yet the public treasury has realized £231,240 profit, after having paid the cost of working and the interest of additional capital.

A NEW GAUGE.—It is proposed, among the schemes for improving London traffic, to make an open railway, with a three-feet gauge, from Islington to the Moorgate Street station of the Underground Railway.

RAILWAYS IN HINDOSTAN.—Four thousand miles of railway have been completed in Hindostan, and one thousand more are projected or commenced.

NEW BOOKS.

DESCRIPTION OF RICHARDS' IMPROVED STEAM ENGINE INDICATOR; WITH DIRECTIONS FOR ITS USE. SECOND EDITION ENLARGED AND REVISED. By CHARLES T. PORTER. London: Longmans, Green, Reader, and Dyer.

This is really a treatise on steam and the steam engine. "Engineering" reviews it in a long article from which we extract the following: Most engineers are familiar with a class of works which, whilst professing to be technical treatises or handbooks, are in reality nothing more than neatly worded advertisements or puffs of some particular machine or invention. To such books as these, that forming the subject of the present notice presents a remarkable contrast.

Mr. Porter has divided the second edition of his work into three parts, about half of the second part and nearly the whole of the third being entirely new. The first division comprises four sections, devoted respectively to an explanation of the nature and use of the indicator, to remarks on truth in the diagram, to a description of the Richards' indicator, and to directions for applying and taking care of the instrument. After explaining generally the action of the indicator and the object to be attained by its use, Mr. Porter enumerates the various sources of error which may operate to produce an incorrect diagram, and points out the means by which they may be avoided.

The second part of the book is divided into two sections, the first being devoted to directions for ascertaining from the diagrams the power exerted by the engine, and the second to instructions for calculating from the same data the amount of steam consumed. Both these matters are treated most comprehensively and clearly; and to this part are appended tables of the areas of circles; of hyperbolic logarithms; and of the properties of steam. These latter, which are very complete, have been prepared by Mr. Porter from the results of the experiments of M. Regnault, these results having been converted into English measures.

The third part of the work, which we consider to be even more important than those which precede it, is divided into five sections bearing the following headings: 1st, Observations on the several lines of the diagram; 2d. On the conversion of heat into work in the steam engine; 3d, The rotative force exerted upon the crank the same for all equal divisions of the diagram; 4th, The diagram not a true representation of the pressure on the crank; and, 5th, Of the motion of the piston as controlled by the crank through the medium of the connecting rod. The second section of the third part, that devoted to a consideration of the conversion of heat into work in the steam engine, is entirely new, and it forms, without exception, the clearest description of the mechanical theory of heat and of the action of steam during expansion that we have yet met with. Mr. Porter's remarks are illustrated by a series of examples carefully worked out, and the theoretical action of the steam deduced from these examples is compared with that which is shown by the indicator to take place in practice. In the next section, Mr. Porter shows that the rotative force exerted upon the crank being the same for all equal divisions of the diagram.

The fourth section of the third part, like the two which precede it, is quite new, and it treats on a subject of the greatest practical importance, namely, the influence exerted by the inertia of the moving parts in modifying the transmission of power from the piston to the crank at the different parts of the stroke. This is a matter to which Mr. Porter has devoted a great amount of attention, and the facts which he points out are worthy of being most carefully studied, particularly by those interested in the construction of high speed engines.

The last section of the book treats, as we have said, of the motion of the piston, as controlled by the crank, through the medium of the connecting rod, and it is accompanied by a most elaborate series of tables, showing, for different lengths of connecting rods, the motion of the piston corresponding to each degree of motion of the crank. These tables, which must have cost Mr. Porter an immense expenditure of time and trouble to calculate, give each result to seven places of decimals, and they are arranged in a novel manner. Each table is composed of four columns of figures disposed in concentric semicircles, the position of each particular result in these semicircles corresponding to the angle to which it relates.

Altogether the book is one which no engineer engaged in the construction of steam engines should be without; and least of all those of our profession—and they are now a numerous class—who are interested in what has been termed "high-speed engineering."

THE HISTORY AND PROGRESS OF THE ELECTRIC TELEGRAPH, &c. By ROBERT SABINE, C. E. London: Virtue & Co.

"Our language," says "Engineering," "is certainly becoming rich in the technical literature of telegraphy. For years it remained almost a barren waste. Mr. Culley first broke the spell, and the success of his work is shown by its having rapidly reached a third edition. Mr. Sabine succeeded, and latterly Mr. E. Brigbt and Mr. Latimer Clark have enriched the science with very valuable additions. The work before us is a second edition of the first portion of the larger work by Mr. Sabine that was published in 1867, and was reviewed by us in our number of February 15th of that year. Its price and size are both reduced. It forms part of Weale's admirable rudimentary series. Much has been added, some parts rewritten, and a good deal expunged. Altogether it is a considerable improvement upon the original, and it is a book which should be in the hands of every telegraphist, for it supplies a gap unfilled by Culley or Clark."

But the reviewer does not agree with the author as to the respective credit due to the fathers of telegraphy. What the reviewer says on this subject will be read in this country with, as the French say, an "uneasy interest." It is as follows:

"We do not wish to diminish one iota the credit due to Morse for the invention of the simplest, most perfect, and most universal telegraph in existence; but we protest against his being allowed priority of claim. We do not object to his immortality. If ideal conversations are to rank as inventions then should Galileo be called the inventor of the telegraph.

"Morse acknowledges having first received the conception of a telegraph in 1832; Wheatstone had been studying the subject years before this. Cooke and Wheatstone's telegraph was patented in the early part of 1837, and Morse's in the latter part of the same year. The first line of telegraph was erected by them in 1838, and the first line constructed in the United States was put in operation in the month of June, 1844. Cooke and Wheatstone's first 'hatchment' telegraph was a beautiful and practical instrument; Morse's first relays weighed 158 pounds, and required two men to carry them.

"We contend that the author's lights in meting out immortality have not been sufficiently luminous. We say Cooke and Wheatstone first, Morse a good second, Steinheil a bad third, and the rest nowhere."

SUGGESTIONS FOR THE SANITARY IMPROVEMENT OF LABORERS' COTTAGES AND OF VILLAGES. By WILLIAM MENZIES, Deputy Surveyor of Windsor Forest and Parks. London: Longmans, 1869.

PRACTICAL APPLICATION OF THE SLIDE VALVE AND LINK MOTION TO STATIONARY, PORTABLE, LOCOMOTIVE AND MARINE ENGINES; WITH NEW AND SIMPLE METHODS FOR PROPORTIONING THE PARTS. By WM. S. AUCHINCLOSS, C. E., late U. S. Commissioner to the Paris Universal Exposition, and author of Report on Steam Engineering. 8vo. In cloth; 58 illustrations, with a valve travel scale. Price $2.50.

This work covers a field heretofore but partially occupied, and develops the fundamental principles of a subject over which, in many minds, hovers a cloud of doubt and uncertainty. Such a sense of vagueness is especially felt when one attempts to follow the intricate motions of a link, and to determine what effects different radii, as well as modes of suspension, must have on the character of the valve motion. It also sorely perplexes the student of steam engineering to discover some fixed principle by which he can at all times instantly determine for a simple slide valve and ports what dimensions will satisfy certain conditions, without following the tedious process of either substituting trial ones in several formula, and solving the same over and over again until, perchance, the right valves are reached, or of placing them on a model and noting their effects; or worse yet, by the geometrical construction of a number of ellipses. The first part of the work before us readily solves all such difficulties by means of an ingenious diagram called the "Travel Scale," from which the engineer can directly measure one after another of the desired dimensions with perfect confidence as to the result. Having explained the nature of the fixed single eccentric motion, illustrated with indicator diagrams the manner in which the action of its valve is affected by the angularity of the connecting rod, and furnished simple means for correcting the same, the author treats of the adjustable eccentric, which he makes introductory to the general subject of link motion. His method of investigating the latter is purely a process of geometrical construction. He entirely rejects the idea that algebraic or trigonometric formulæ are capable of here rendering any practical assistance. The plan of procedure is clearly defined and many means explained for varying the results. As the true radius of the link and position of the center of suspension are thereby determined with the greatest ease, the draughtsman can with its aid quickly scheme a satisfactory link motion without resorting to an expensive link model. The shifting, stationary, Allan and Walschaërt link motions are consecutively examined, and their points of similarity compared. The subjects of independent cut-off, clearance, friction, etc., have likewise received due consideration. To the draughtsman, master mechanic and student of steam engineering this little work will prove a most invaluable assistant, not only preventing the occurrence in designs of mortifying mistakes, but greatly economizing the time of execution.

EXPOSITION MARITIME INTERNATIONALE DU HAVRE. 1868. RAPPORTS DU JURY INTERNATIONAL. London: JOHNSON & SONS.

The rapidity and completeness with which the jury reports of the Havre Maritime Exhibition have been published presents a striking contrast to what we have hitherto been accustomed. It is compiled in two languages—English and French—and contains a complete list of awards as well as the reports of the juries. As to its accuracy we are not in a position to speak, but there can be no doubt of its excellence in a typographical point of view. Every care appears to have been taken to ensure correctness, the proofs having been submitted for final revision to the president and reporter of every class or section, they being held responsible for the accuracy of the awards and the motives assigned for them. The original intention of the promoters of the Exhibition was that it should follow immediately the "Universal" at Paris, and be supplementary to it. The docks at Havre enabled the jurors to establish a species of competitive examination of vessels afloat, and to test the improvements that had been made of late years by inspecting, not merely models on a large scale, but the ships themselves. With few exceptions, all foreign nations, England especially, co-operated by sending liberal contributions. A very novel feature in the Havre Exhibition was the election of the jurors for each class by the suffrage of the exhibitors, an arrangement which proved highly successful. The compilation of this work, containing nearly 600 closely printed pages, must have been a task of considerable difficulty and responsibility. The mode in which it has been accomplished is highly creditable to the publisher, to whom the undertaking was entrusted by the Commission of the Exhibition.—*Engineering.*

THE ROYAL ENGINEER. By the Rt. Hon. Sir FRANCIS B. HEAD, Bart. London: John Murray, 1869.

Sir Francis Head certainly deserves well of the Royal Engineers. He has visited Chatham, and has inspected the Mounted Engineer Train at Aldershot, and has committed the results of his investigation to print. It is well that somebody has done so, for otherwise the solid work which is done by the most scientific branch of the army might have passed unnoticed. We now know the composition and working of the photographic and electrical school at Chatham, as well as the whole means which are adopted at the Royal Engineer establishment to train the sappers and miners of the British army in photography, surveying, field works, and the construction of entrenchments. Sir Francis Head describes the Royal Engineer *ab ovo*. He relates how he is first admitted into the Royal Military Academy at Woolwich, educated there, and in a chrysalis state transmitted to Chatham, where he completes his practical and technical instruction. He even describes the various schools at the Engineer establishment, at which the non-commissioned officers and men are prepared for their several duties. Each different species of them requires a separate training and separate instruction. The draughtsmen, the surveyors, the photographers, the electricians, are all subjected to diverse treatments, which are clearly recounted in the book before us. Those who wish to find all that pertains to the preparation of both officers and men of the Engineers for their duties both in the field and at the desk, as well as any who are interested in the requirements for obtaining a commission in that corps, will derive much value from Sir Francis Head's work.—*The Engineer.*

A large, carefully prepared work on military engineering; octavo; 400 pages.

THE ELEMENTS OF HEAT AND OF NON-METALLIC CHEMISTRY. By FRED'K GUTHRIE, A.B.(Lond.), Ph. D., F. R. S. E. London: Van Voorst. 1868.

Mr. Guthrie evidently thinks that even elementary treatises like those of Balfour Stewart are of too difficult a character, and that works like that of Lardner are too general for the requirements of the London University. He has, therefore, attempted to compile a book which, while avoiding the mathematical details of higher treatises, should bring together, in clear and intelligible language, the leading phenomena and laws of heat and of non-metallic chemistry. His endeavors have been in some measure successful, and in some degree also have failed in their purpose. For instance, while he has treated the subject of heat in accordance with the aim he had in view, he has fallen short of his aim in dealing with the chemistry of the non-metallic elements.—*Popular Science Rev.*

MISCELLANEOUS.

MACHINE BUILDING IN EUROPE.—There are many and large—some of them very large—engineering establishments upon the Continent, and they appear to be busy, busier than works of the same class in England. Besides the large engine works of the French government at Indret, near the mouth of the Loire; and the large railway workshops of the six great French railway companies, there are, in Paris, the works of Cail and those of Gouin, employing at times, the first 2,000 and the second 1,000, or more, men. There is the great establishment of Schneider & Co., at Creusot; the fine locomotive works (we have none better nor larger) at Fives, near Lille; the large works of André Koechlin & Co., at Mulhouse; the Graffenstadten works on the Rhine; and, as for marine engine-makers, besides those at Indret, and Schneider & Co's, the large works of Mazaline & Nillus at Havre, and those of the Mediterranean Company at Marseilles. The Creusot works alone employ between 9,000 and 10,000 workpeople in all departments, and few of the others named employ less than 1,000, and some of them very many more.

In Belgium there are the great Société John Cockerill, employing many thousands of hands, the Couillet Company, the Société St. Leonard, and others. In Holland there are the large iron ship-building and engineering works of Paul Von Vlissingen & Dudok Von Heel, at Amsterdam. In Switzerland are large works at Zurich, viz: those of Escher, Wyss & Co., of which Matthew Murray Jackson, an English engineer, is manager; and in Bavaria are the large bridge building works of Klett & Co., of Nuremburg, and the smaller engine works of Maffei, at Hirschau, near Munich. There are extensive engine works also at Carlsruhe, in Wurtemburg, and there are machine making establishments of various degrees of magnitude scattered over a large portion of the Continent.

Borsig, of Berlin, some time since turned out his 2,400th locomotive; he sent his 2,000th to the Paris Exhibition. Experts speak in high terms of the character of Borsig's workmanship, ranking it much above that of the French and Belgian engineers. He employs steel very largely, much of it of his own manfacture, and he gives a high degree of finish, not only to the working parts, but to some others which with us are painted. His contracts are largely upon Russian account. Borsig's large iron works at Moabit, four miles out of Berlin, have been converted into a great boiler factory, and his iron makers are being transferred, to the extent of one thousand families of workpeople, to a new establishment in Silesia.

Hartmann, of Chemnitz, in Saxony, now employs 1,800 men and boys, and is constructing machinery of almost every class. He has lately built an erecting shop, to receive thirty-five locomotives in a single row, and, allowing no more than sixteen feet from center to center of pits, this building must be upwards of 550 feet long. His make of engineers' tools, cotton and woolen machinery, turbines, &c., is very large.

PATENTS.—About 4,000 "provisional protections" are granted yearly at the British Great Seal Patent Office, the protections granted being within, perhaps, a dozen or so of all the applications made. Of these protections only about two-thirds pay the additional £20, which gives them the force of a patent. At the end of three years from the original grant the patent lapses unless £50 more be paid, and at the end of seven years from the grant £100 more must be paid to continue the patent for the full term of fourteen years. In the year ending September 30th last, 14,153 patents, re-issues and protections of designs were granted by the United States Patent Office. Over 20,000 were applied for.

THE INTRODUCTION OF STEAM FIRE ENGINES.—Steam power for extinguishing fires was in use in manufacturing establishments many years before it was employed on portable machines. Every factory of any pretensions had its steam-driven pump with hose and other attachments calculated to reach every portion of the establishment. About the year 1829 or 1830, Capt. Ericsson, then of the firm of Braithwaithe & Ericsson, London, England, built and exhibited a portable steam fire engine. In 1842 or 1843 he produced a similar engine in New York city, and it was tested but never brought into regular service. The writer remembers a great objection urged against its use, that it burst any hose that could be made, which showed that the fault of want of success did not lie with the machine.

So far as we are informed, the credit of overcoming prejudice and successfully introducing the steamer in cities and large towns belongs to Miles Greenwood, when mayor of Cincinnati, Ohio. Mr. Greenwood, being a man of great tenacity of purpose and a thorough mechanic, and having, moreover, the confidence of his fellow citizens, succeeded where only failure awaited others; and, in consequence, Cincinnati was the first city to adopt the steamer as a permanent portion of its fire department force.

The reasons why this most efficient agent—steam—was not sooner utilized for the protection of property from fires, may be summed up in one word, prejudice, prejudice born of ignorance. Fire and steam careering through the streets instead of inducing confidence and a feeling of security, inspired terror or created apprehension. Our municipal authorities, too, are not generally engineers or mechanics—and—the steamer does not vote.

The metropolitan fire department of New York city numbers 34 steamers of about 50 H. P. each, equal to 185 men, or, in the aggregate, 6,290 men, while the actual number of men employed, even adding the 12 hook and ladder companies, is only about 550: thus relieving 5,740 men from the labors, dangers, and the exposure of the fireman, and allowing them to become producers rather than merely protectors of property. The time is past to question either the superior efficiency or the economic advantages of the steamer over the hand engine. As well might we return to the old hand press and the spinning wheel, print our newspaper editions of 100,000 daily and clothe the teeming millions by hand labor, as to discard the powerful agency of steam in the protection of our property from fires.—*Scientific American.*

NEW GALVANIC BATTERY.—A new battery is announced as arranged by M. P. Guyot, which may be useful for telegraphic purposes and electrical alarms. It consists of a porous earthen vessel filled with finely-powdered iron ore, in which is plunged a cylinder of gas retort charcoal and an ordinary vessel filled with concentrated solution of common salt, in which is placed a slip of zinc. The only care required to keep such a battery in order is to keep the latter vessel always full of concentrated solution.—Further, the solution may be replaced by sand impregnated with it or by salt in crystals, the humidity of the atmosphere being always sufficient to serve as a solvent. If the latter form be found to answer, the battery would be extremely convenient on shipboard, in trains, or wherever there is motion.

A MUCH NEEDED BOOK.—Our publishers have many inquiries for a work on the *American Steamboat Engine*, containing engravings (not necessarily costly) and details of valves and valve gear, and other parts and their working. A book is wanted that will teach a mechanic having some theoretical knowledge or a student having some practical ideas, how to set the valves and operate and maintain this kind of engine to the best advantage.

THE AMERICAN MASTER MECHANICS' ASSOCIATION.—We take pleasure, says the "Western Railroad Gazette," in laying before our readers a few facts connected with the objects and operations of the American Railway Master Mechanics' Association, now approaching the third year of its existence. This association is composed of the master mechanics of the railways of the United States, whose object is that of improving the motive power of the several roads which they represent, and also determining the best and most practical as well as the most economical system of construction and management thereof. For this purpose committees are appointed among themselves to report upon the different subjects connected with their department of railway management. These reports and the attendant discussions are published for the benefit of the railways at large. We are confident that no mechanical association has been found comprising a greater degree of practical intelligence; and when it is borne in mind that this report will embody the combined experience of over two hundred of the ablest mechanics and engineers of our country, it will at once be understood how valuable a text book these reports will make. Mr. L. P. Dodge is the secretary of this committee, and is now making the tour of the United States, visiting each master mechanic, and, in person, procuring data and information for the required reports. Perhaps the most important committee for the coming year is that upon "boilers," composed of Messrs. Hayes, Illinois Central Railway; Jauriet, Chicago, Burlington and Quincy Railway; and Anderson of the Chicago and Northwestern Railway; as it is to take up the question of *steel plates* as a substitute for iron or copper, and we are informed that thus far the experience of many of the largest roads is largely and unmistakably in favor of its use, especially in coal-burning locomotives. Their next meeting is to be held at Pittsburg in September, due notice of which will be given.

BLEACHING OF WOOD-PULP FOR PAPER.—M. Orioli, a French chemist, says, in the "Revue Hebdomadaire de Chimie," that the chloride of lime, if the dose is the least in excess, has a tendency to give a yellow tinge to the pulp; that all energetic acids, without exception, tend to give a reddish color to the paper when exposed for a long time to the effects of the sun or of moisture, and that the least trace of iron is sufficient in a very short time to blacken the pulp. He says he has succeeded in avoiding all these inconveniences by the use of the following mixture: For a hundredweight of wood-pulp, he employs 400 grammes (four-fifths of a pound) of oxalic acid, which has the double advantage of bleaching the coloring matter already oxidized, and of neutralizing the alkaline principles which favor such oxidation; he adds to the oxalic acid one pound, or a little more, of sulphate of alumina, entirely deprived of iron.—The principal agent in this mode of bleaching is the oxalic acid, the power of which over vegetable coloring matters is well-known; the alum has no bleaching power of its own, but it forms with the coloring matter of the wood an almost colorless lake, which has the effect of increasing the brilliancy of the pulp.

THE EFFECT OF COLD ON TIN.—It is stated in a recent number of the "Comptes Rendus," that according to Herr Fritsche, tin exposed at St. Petersburgh last winter to a temperature of 40° below zero was converted into a semi-crystalline mas containing cavities like basalt. In masses of tin weighing from 55 lb. to 66 lb. these cavities in some cases had a volume amounting to nearly 24 cubic inches.—According to M. Dumas, facts of this kind are no new in Russia; for instance, in one case the pipes of a church organ were so altered by the cold as to be no longer sonorous.

NEW HORSE SHOE MACHINE.—Some interest has been excited in Birmingham by a new machine for the manufacture of horse shoes, invented by M. Bastien, Paris. The principle of the invention is the hydraulic press. The process is as follows: Immediately the bar comes red hot from the furnace the iron is transferred to the rolling mill. Here a movable piece on which the bar is placed receives an alternative motion from two pistons of the hydraulic press. This movable piece presses the bar between two left-hand sliding surfaces, which impart to it a bend. It is next very strongly pressed on a die, thus receiving the definite form, while at the same time the nail holes are pierced, and by means of a spring the movable piece recedes and allows the finished shoe to fall out into a shallow tank of water placed underneath. The action of the machine suffices to make a shoe at each motion, forward and back, thus preventing any waste of power. The dies and stamps are easy of adjustment, and may be immediately exchanged for the production of larger and smaller shoes at discretion. Two pressures are necessary, namely, one of from four to five atmospheres to produce the form of the shoe, and another of from 100 to 150 atmospheres to pierce the nail holes. A movement of from six to eight strokes per minute can easily be obtained by this machine, producing as many shoes as strokes. The success which has attended the invention on the Continent is likely to be supplemented in this district by ironmasters at present engaged in the production of horse shoe bars.—*The Engineer.*

VALUE OF EUROPEAN PATENTS.—The American origin of an invention is now a recommendation in Europe, where many of these inventions are in successful operation, and large fortunes have been realized by their introduction. Improvements relating to some manufactures are of great value in this kingdom. Mr. Bessemer derives an annual income of about $2,000,000 from his British steel patents, and the patentee of a device for dressing mill-stones, by a revolving diamond, has realized over $1,000,000 the first year of his patent. The use of a diamond for this purpose is an American invention, and the estimated value of the exclusive right in England, for ten years, is $5,000,000. British patents, as a rule, are the most valuable, but many inventions are equally profitable in other parts of Europe, and some are peculiarly adapted to continental wants and customs.—*Hazletine, Lake & Co's Circular.*

THE CALIFORNIA BIG TREES.—Within a space of fifty acres, in the Original Grove, there were (in 1865), 103 trees of great size, twenty of which exceeded twenty-five feet in diameter at their base. The "big tree stump" had room enough for thirty-two persons to dance four sets of cotillions at the same time; besides many musicians and spectators. Across the solid wood of this stump, at 5½ feet from the ground (*without* the bark, which equalled 15 to 18 inches in thickness), it measured 25 feet. This glorious tree was sound to its center, and was 302 feet in height and 96 feet in circumference at the ground. The "Father of the Forest," the *largest* tree of the entire group, measured in circumference, at the ground, 110 feet.

GERMAN LOCOMOTIVE PRICES.—Herr Borsig, of Berlin, has recently received an order from the Rhenish railway for twelve locomotive engines and tenders for working passenger or goods trains. The engines weigh, empty, thirty tons, sixteen cwt. and the tenders eleven tons, four cwt; the price of each engine and tender is £2,625.

THE HEAVIEST LATHE.—The Lowell machine shop is now building the heaviest turning lathe in the country, to weigh seventy tons.